News Round-up

New Headquarters for Oversea Service

With the British Government's financial assistance, 'Oversea Service', an organization which prepares people for conditions they will meet in overseas territories where they go to work, is leasing twelfth-century Farnham Castle in Surrey, Southern England, for use as a headquarters. The Governments of Hong Kong, Jamaica, Sarawak, Malaya, Nigeria and 12 other African Governments, as well as British Government Departments and large numbers of British businesses, send staff to its educational courses.

Rabbits Used to Carry Sheep Embryos

A new technique developed by two British scientists by which rabbits have been used to carry fertilized sheep ova from Britain to South Africa is considered in Britain to have considerable commercial possibilities. Fertilized ova from Border Leicester sheep at Cambridge were recently transferred to rabbits and flown to Pietermaritzburg where they were placed in Dorper sheep. After normal pregnancy the sheep gave birth to pure-bred Border Leicester lambs.

The system has been developed by Dr. C. E. Adams and Mr. L. E. A. Rowson at the Unit of Reproductive Physiology and Biochemistry. It is claimed to be cheap and has the advantage that no quarantine restrictions are imposed for embryos.

Reclaiming Land in Pakistan

Investigations to help Pakistan make use of every available acre of her agricultural land are being carried out by a United Kingdom firm of land use and geological consultants—Hunting Technical Services Limited. The investigations, into drainage and salinity control, are aimed at determining the extent of problems and deciding which remedial measures will best suit the regions involved. A pilot project of some 5,000 acres will be set up soon to compare construction and maintenance costs of land drained by open and by tile drains and to provide a centre for carrying out various reclamation trials.

More Overseas Students in Britain than Elsewhere

There are far more students from abroad in Britain, relative to population, than in any other country, states the British weekly, *The Economist*, in a recent issue. It quotes British Council estimates that in the last academic year there were 47,520 overseas students attending courses of longer than six months in Britain and of these 30,880 came from Commonwealth countries. The total figure of more than 47,000 overseas students compares with preceding years as follows: 1956-57—about 37,000 overseas students; 1953-54—about 24,000; 1950-51—about 13,000.

Sudanese Awarded First Cotton Scholarship in United Kingdom

A one-year scholarship, the first of its kind to be awarded, has been granted by the Empire Cotton Growing Corporation in Britain to Sayed Mirghani Abdalla Mirghani, an official of the Sudan Gezira Board. Sayed Mirghani is expected to arrive in Britain in the autumn and will undertake his studies at, it is hoped, the University of Cambridge. The scholarship was founded last year and will be awarded to member countries of the Corporation on a rota basis. Its purpose is to give further training to promising agriculturalists and other specialists connected with cotton growing.

British Air Company Helps to Map Africa

The Fairey Company Limited of London is playing an important part in the development of Africa—particularly in some of the new independent States—through its aerial photographic units. The firm is at present engaged on three major projects in Nigeria where one of its aerial photographic teams is covering 25,000 square miles in the three regions of the Federation. In Uganda, townships are being mapped, and maps of Tanganyika townships are also nearing completion in the Company's photogrammetric laboratories in Southern England.

World Centre for Research on Honey Bee

A world centre for knowledge gained from research on the honey bee is to be established in Britain. The centre will be run by the Bee Research Association which acts as a central link between research workers and beekeepers throughout the world. The Association, whose work has been recognised by grants from British and other Commonwealth governments, was started in the United Kingdom twelve years ago and now has members in 76 countries.

Growth in British Aid to Underdeveloped Countries

Britain's new bilateral contributions to underdeveloped areas in the period 1956-59 totalled over £1,033 million. This figure comes from a study made by the Organization for European Economic Co-operation (O.E.E.C.) and entitled 'The Flow of Financial Resources to Countries in the Course of Economic Development, 1956-1959', which has been published in Paris.

British private investment over the four-year period totalled over £714 million, and official contributions amounted to £320 million, of which three-fifths was in grants. The report adds that net new official loans have risen sharply since 1958 and that, usually, loans and grants made from the British Exchequer are in fully convertible sterling and may be used for imports from any source or for local expenditure.

United Kingdom Trust Aids Medical Research in East Africa

Aid for human and animal medical research in East Africa from the Wellcome Trust during the past few years has ranged from provision of £100,000 sterling for the Foot and Mouth Research Institute near Nairobi to the payment of travelling expenses to enable East African experts to study new developments in other countries.

The Wellcome trustees use funds from Sir Henry Wellcome's will to support medical research work anywhere in the world and to help museums and libraries serving the special interests of medical research and history.

In Uganda, the Trust gave £12,500 to build an animal house and to supply Makerere College with a mobile field laboratory for use in comparative physiological studies of some of the larger fauna of tropical Africa.

Two research workers employed by the Trust in Nairobi, Dr. Henry Foy and Dr. Athena Kondi, are carrying out research into different types of anaemia which are prevalent in East Africa. Recently they have been using radioisotopes for studying iron metabolism and iron loss.

Major Agricultural Research Project in Iran

A survey in Iran of the incidence of microscopic plant parasites called nematodes which cause enormous damage to crops will be carried out by a Ministry of Agricultural Scientist, Mr. Abdol Majid Omidvar who, for the past three years, has been undertaking specialized study in Britain. He will be the first qualified nematologist—one of the newest sciences in agriculture.

Mr. Omidvar said recently: 'My Government agrees with the world's foremost scientists that an investigation would not only benefit Iran but countries of the Middle East generally.' The next step—after the investigation—will be to devise methods of controlling the parasites by chemical means.

Extension of Locust Information Service

As part of the United Nations Special Fund Desert Locust Project, the scope of the Desert Locust Information Service is now being extended by the use of current weather data to help to interpret the current locust situation and to forecast its future development.

With the co-operation of the World Meteorological Organisation and of national meteorological services, detailed observations of current weather over most of the invasion area reach the Anti-Locust Research Centre in London daily through normal meteorological telecommunication channels, and within a few hours of the time of each actual observation. Such observations are being received from nearly 100 meteorological stations in nine countries which are at present infested by the Desert Locust. This up-to-date weather information is already making possible, in some cases, the provision of special telegraphed warnings of imminent locust developments affecting individual countries. The scope and value of such warnings is, however, entirely dependent on correspondingly prompt and precise locust reporting.

Some Problems of By-product Manufacture in Less Developed Countries*

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Summary

The paper aims to dispel a widespread misconception in tropical countries that full use of animal offal can be achieved only with costly equipment, and under conditions comparable to those in large meat-packing factories. This attitude leads to the paradoxical situation that nutritious raw materials such as blood and bones are wasted, while expensive blood meal and bone meal are imported. Even hides and skins are sold and re-imported as finished leather. The benefits to be derived from hygienically produced by-products in terms of less malnutrition among human beings, healthier livestock, better crops and the creation of new industries, are described. The structural requirements for a modern by-products plant are stated and illustrated by a plan.

The Challenge

The large American meat-packing plants were the first to realize that it is a great financial and sanitary advantage to make the fullest use of each slaughtered, dead or condemned animal. The method of utilization of even the smallest and cheapest part of the animal was perfected to such an extent that today it is truly stated that only the 'moo' of the cow escapes. This approach is relatively easy with adequately capitalized establishments dealing with vast throughputs. Similarly, in progressive industrial countries with large consuming areas and relatively small distances between slaughterhouses, a centrally situated by-product plant, making use of raw materials derived from several sources, was not difficult to establish. Unfortunately, such favourable circumstances rarely occur in less developed, tropical countries.

It is regrettable that, in most under-developed countries the approach towards the slaughter of animals is unimaginative, leading to wasteful losses of a whole range of valuable by-products. The erroneous belief that costly machinery, highly-skilled staff and fully-equipped laboratories are necessary to produce useful by-products leads to a paradoxical situation: those countries, where the need for proteins and minerals for man, beasts and the soil is greatest, are the ones which make least use of them. Examples of this policy are the practices of dumping blood while importing blood meal, exporting bones while importing costly cattle lick, throwing offal to the jackals while importing proteins, and selling hides and

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skins while repurchasing the same as finished leather. From the economic and sanitary point of view, it is essential to make use of all the raw materials in each slaughtered animal, turning them into an extensive and valuable range of secondary products. This, then, is the challenge, not only to the large factory abattoir, but also to the smallest rural slaughter-slab and to those who slaughter only for their own needs.

The raw materials suitable for by-product manufacture vary widely, both in quantity and quality, not only between continents but from country to country and even within districts. The definition of by-products is vague. It is easy to associate a liver or a kidney with an animal, but insulin, cortisone, strings for musical instruments, or glycerol are rather remote derivatives of the slaughtered beast. Basically, the terms 'by-products' and 'offal' are used to denote every part or particle which is not included in a dressed carcase. Organs, such as kidneys, brain, liver, heart, tongue, oxtail, the intestinal tract, gullet and sweetbreads, are called edible by-products. Animals which die at the slaughterhouse prior to slaughter, or those animals, or parts of animals, which have failed to pass meat inspection as fit for human consumption, fall into the category of inedible by-products. Teeth, gall-bladder, hooves, horns, hair, bristles and dew claws are similarly inedible. Other products which, though potentially edible, may be considered as inedible due to improved standards of living, local customs or religious restrictions include the uterus, spleen, lungs and blood. These may be considered fit for human consumption provided they are derived from sound animals and were not contaminated during slaughtering or dressing.

With higher earnings, consumption of meat increases and, at the same time, there is a demand for better quality. In consequence, certain parts of the animal become unsaleable and have to be converted into stock feed. For instance, in the United States, the whole of the head, the feet, most of the tripe, and certain other parts are as a matter of routine converted into stock feed because no market exists for these commodities for human consumption. What is termed 'inedible offal' in industrialized societies may hardly exist at all in certain under-developed territories. Spleen and genital organs may be consumed regularly, and even parts of the hide, such as the mask, the shoulder and shanks are used for edible purpose. In such circumstances, little is left for by-product manufacture. However, large quantities of condemned material may be available from condemnation of animals which are heavily infested with measles, fevered due to tick or tsetse fly-borne diseases, emaciated because of drought, or badly bruised as a result of unsatisfactory transport over long distances.

Principal and Secondary By-Products

Offal can be subdivided into principal by-products and secondary by-products. The principal by-products include hides and skins, bones, blood, hooves and horns. The secondary class of by-products includes a wide range of items manufactured from the principal by-products; for instance, blood yields blood meal, fibrine, haemoglobin, blood albumen and so on.

The time is rapidly passing when livestock is bred for prestige only, when numbers and not quality are the aim of breeders. A progressive stockowner requires from his livestock meat, milk, progeny, work, wool and eggs; he is no longer satisfied merely to count it.

The supplementation of poor-quality stock feed by valuable proteins, minerals and vitamins derived from waste products leads to better livestock, and consequently to more food for humans. This is a positive approach to the public health problems in all under-fed people. The provision of proper and adequate nutrition must be the ultimate aim.

The Benefits of By-Products

A. Improved Environmental Sanitation

Blood, trimmings, fleshings, condemned organs, and, in fact, all unused offal, attract flies, rats, jackals and stray dogs. The sanitary disposal of such by-products is very difficult as they tend to clog drains and pits and to decompose rapidly, producing objectionable smells and forming an ideal breeding ground for meat-spoiling organisms. Meat slaughtered and kept under such insanitary conditions not only has poor keeping qualities but is a danger to health. Burning and burying inedible offal means the total loss of potential by-products and, unless properly carried out, may also help to spread disease. The buried carcase is often dug out by carrion or even by humans. In certain countries, the owner or the butcher is compelled by law to burn or bury a condemned carcase under the supervision of a meat inspector. Obviously such a procedure tends to create hostility between the butcher and the meat inspector or to lead to unauthorized bush killings.

The simplest way to use inedible slaughterhouse by-products is to feed them direct to pigs and poultry kept in the vicinity. This is crude and unsatisfactory from the public health, veterinary and animal husbandry viewpoints. Similarly, the manuring of the fields with blood, ruminal and intestinal contents, is rarely satisfactory and does not dispose of all the organs such as hooves, horns and condemned parts. Agricultural activities cannot be adjusted to the slaughterhouse throughput and raw materials must be preserved until they are required.

Obviously, it is better to produce sterilized, concentrated products suitable for stock feed. The process of concentration and preservation depends on the reduction of the moisture content to the point where bacterial multiplication is prohibited. Sterilization of the by-product is another basic principle of production, as otherwise disease may be disseminated by pathogens present in the raw material.

The installation of a by-product plant solves all problems of disposal satisfactorily and hygienically. Material can be removed rapidly, and hot water and steam are readily available from the by-product plant boiler, making it possible to clean the slaughterhouse, equipment and protective clothing easily and efficiently.

The organization and supervision of the human element working in slaughterhouses is much easier once the place for disposal of condemned parts and inedible offal is to hand; poverty and the low educational standard of labour often lead to the unauthorized removal of such offal.

B. Healthier and More Productive Livestock

The use of bones is an excellent example of the role played by waste animal products in the improvement of livestock.

Vast areas of less developed territories have soil and pasture deficient in phosphorus and often in calcium. Animals grazing on grass deficient in these minerals are unable to make full use of the food available. They are slow to mature, breed irregularly, bear dead or weak offspring, and there is loss of meat and milk production and increased susceptibility to infectious and parasitic diseases.

Modern methods of animal husbandry make possible a higher output of meat, milk, progeny and work. Phosphorus, being a vital component of the proteins forming the living cell, is essential to maintain life and production. The semi-arid or arid areas, where most of the livestock is bred, yield mature, weathered forage, resembling straw, which is high in fibre and lignin, and the phosphorus deficiency which becomes more severe as the forage matures, further reduces fodder utilization. Legumes, being sensitive to lack of phosphorus, are scarce or absent. Silage and haymaking are either unknown or unwillingly accepted; fertilizing of pastures is non-existent, and the impoverished soil, with continuous cropping and depletion of phosphorus and calcium, is unable to provide these elements.

Phosphorus deficiency can be remedied by wide-scale soil dressing with phosphatic fertilizers. Such a solution is totally uneconomic, except in a few areas of very high potential. Luckily, phosphatic deficiency of livestock can be easily remedied by feeding phosphates; the best form of such phosphate is sterilized bone meal made from bones available locally.

Concentrates

The availability of bone meal is the first step in the production of mineral supplements in the form of powder or bricks. By the addition of salt and trace elements, such as copper, iodine, cobalt and iron, bone meal can be converted into a complete mineral supplement. The introduction of this enriched bone meal into stock rations helps the breeder to produce better livestock and slowly enriches the pastures, formerly lacking in such basic elements.

The failure to use blood is another example of wasteful handling of valuable raw material. When dried, it represents a concentrated food of the highest possible protein content, and is a most valuable source of vitamins. Blood meal contains over 80 per cent protein, representing large amounts of lysine, tryptophane and methionine, and is therefore particularly valuable as a supplement to carbohydrate feed and meat meal in which the main nutritional limiting factors are the low content of the three above-mentioned amino acids. Taking 5 lb. as the potential amount of dried blood from every large beast slaughtered, and $\frac{1}{2}$ lb. from every sheep/goat, the waste of protein where blood is not utilized is prodigious.

Meat and bone meal, or 'carcase meal', is not only a source of extremely valuable protein but also supplies phosphorus and calcium as well as vitamin B.12, essential for growth. Whether, in addition, an unidentified

growth factor is present in proteins of animal origin is a matter of dispute. Proteins derived from meat or blood are well suited to correct the deficiency of amino acids present in the grass or grain. Because products such as meat meal, blood or liver meal contain practically no fibre, they are called 'concentrates', as they add little to the bulk of the ration. Such concentrates are extremely important in pig and poultry feeding, as they give the animal more protein without increasing the volume of the feed. Animal protein concentrates fed to fish help to increase the yield of fish in ponds and dams. Fish yield from properly-managed waters will far exceed the yield of protein per acre of arable land. Low-grade fats and grease unsuitable for human consumption will, when mixed into poultry rations, not only control the dustiness, but also make the feed more nutritious by acting as high calorific fuels.

Fertilizers or Stock Feed?

Whether to manufacture fertilizers or stock feed is the question which the potential producer must ask himself. The essential difference in the production of fertilizers and stock feed lies in the speed with which they are handled and the freshness of the raw material. Meals made from partially-decomposed blood and meat will obviously be unpalatable to the animals and fit for fertilizer use only. Such products are quite unsuitable for stock feed since, during decomposition, much of the protein is denatured, and, in consequence, is of little nutritional value. Unsterilized bone meal may be dangerous to stock and is suitable only as a fertilizer. Because fertilizers of animal origin must compete with synthetic fertilizers such as urea or super-phosphate, they fetch a very much lower price than if the raw material had been converted into stock feed. It is therefore imperative to provide adequate sanitary arrangements for the conversion of all slaughterhouse offal into products fit for stock feed.

A basic principle governs the manufacture of by-products. Under no circumstances and no matter how cleaned or changed the final product may be, edible products cannot be made from truly inedible material. For example, sweepings or inedible organs or fat from animals which have died naturally or been condemned can never become edible, no matter how bleached or refined.

Every slaughtered beast should contribute the maximum of animal protein for the human population, and such contribution must be both directly, in the form of fresh meat and indirectly in the following ways. Firstly, animal protein (derived from the offal of the slaughtered beast) is quickly converted into stock feed for pigs and poultry who will, in their turn, provide protein for man, and, secondly, the bones of the original carcase are converted into sterilized bone meal rich in minerals for feeding to other stock. In this way, a cycle is created; more bacon, eggs, poultry, fish, pork and rabbit appear on the table as the result of the consumption by live animals of the proteins and minerals made from slaughtered animals.

This is the challenge, therefore—the creation of a by-product industry, not to export, but to put into circulation the proteins, minerals and

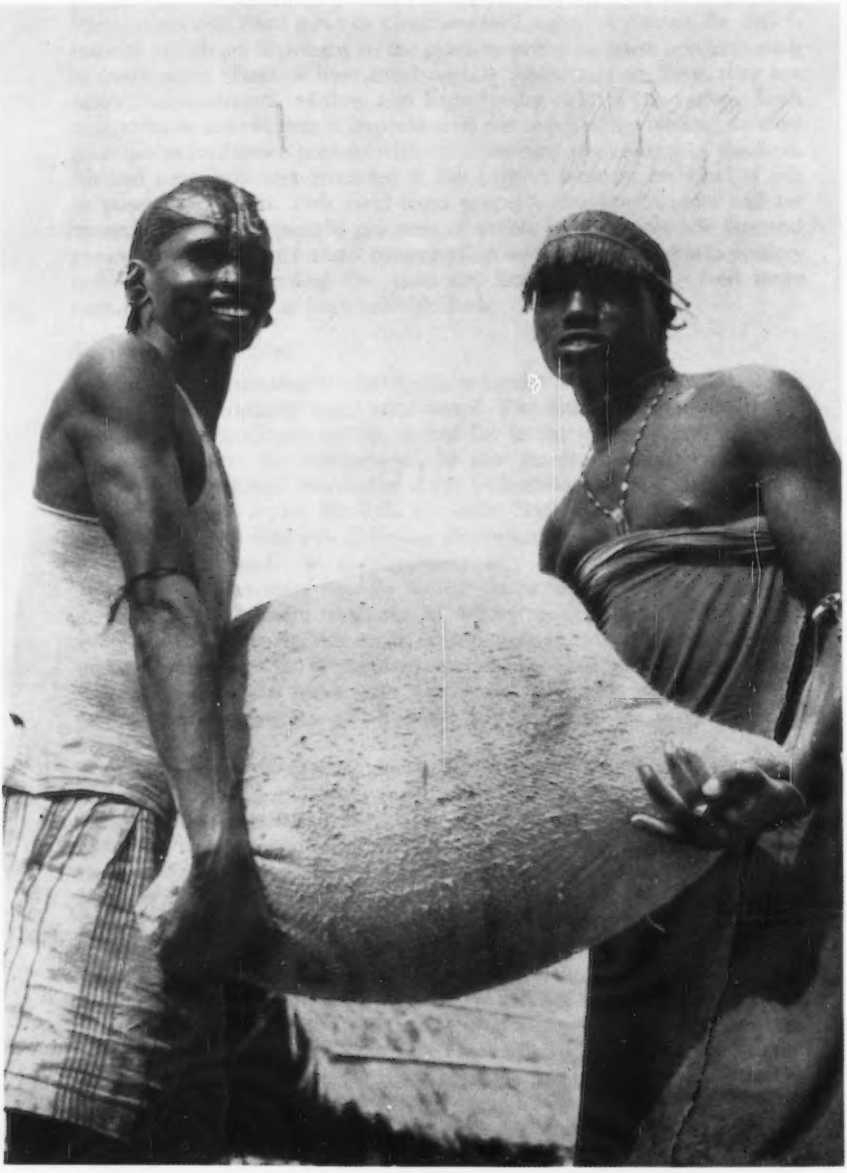

PLATE I. Bone Meal to Improve the Pastoralists' Livestock

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vitamins for the benefit of the stock, the stockowner and the consumer. (Plate I.)

More protein means reduced infant mortality, more vitality and vigour in those who now survive, less kwashiorkor, and less damage to the liver caused by high carbohydrate diets in adults. All lead to greater human efficiency and happiness.(1)

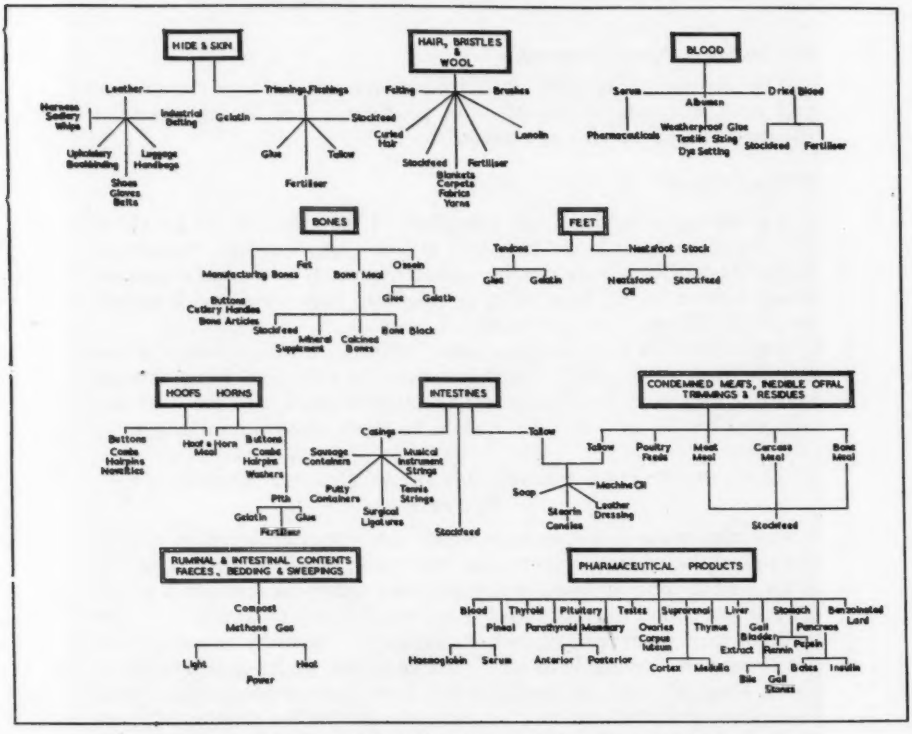

FIG. 1. Diagram of the Main By-products of Animal Origin

C. Secondary Industries

The manufacture of by-products of animal origin leads to the establishment of local industries; for example, the production of hides and skins of high quality provides a sound base for a tanning industry; the availability of tallow and other greases will lead to the local manufacture of soap; hides and skins, trimmings, sinews and tendons are excellent for making glue; ear and tail hair and bristles are suitable for brushes; glands will yield a range of life-saving pharmaceuticals; sterilized bone meal provides the major raw material for making mineral licks for livestock; meat meal and blood meal are the basic ingredients of cheap stock feed; inedible fat can be used in a high calorific diet for broilers; foods for dogs, fish and fur-bearing animals can also be made.

D. Price Structure

By-products influence the price of meat and the price paid to the producer for livestock. The return derived from by-products may be used to cheapen the price of meat to the consumer or to give the livestock producer a higher price for his beast. Thus, when the problems of by-product utilization are under discussion, the support of both the meat consumer and the livestock producer should be enlisted.

E. Creation of New Employment

The conversion of offal into by-products creates new employment and skills not only at the place of production but in the secondary industries based on such raw materials.

F. Better Crops

The nitrogen, calcium and phosphate of the offal can be converted into fertilizers to increase the yield of fields, gardens and plantations. Imported fertilizers may not be within the reach of the poor peasant, whereas dried blood, bone meal or hoof and horn meal, made locally, would be of great assistance to him.

Compost made from slaughterhouse offal and bedding from the lairs can increase crop yields. Methane may be produced from compost material and used to illuminate the slaughterhouse and for heat and refrigeration. Figure I shows the main by-products of animal origin.

Concessionally Passed Meat as Direct Source of Protein

The conversion of by-products which are not directly edible such as meat meal, blood meal, carcase and liver meal, into new forms of protein fit for human consumption is a slow process yielding far less than a pound of meat per pound of stock feed fed and requires capital and labour. The methods used in developed, rich countries with wealthy consumers are not necessarily applicable to other, less fortunate, under-developed territories. Here, all products available for direct human consumption must be used to the full. Blood may be converted into edible blood meal, tripe into edible tripe powder, livers into liver meal, and certain conditionally passed animals, or parts thereof, may be used for sterilized products, such as meat powder.

The aesthetic reasons which lead many meat inspectors in industrialized countries to reject inferior meats may need to be adjusted to the local nutritional needs and hygienic standards. Under this category, perhaps, falls the animal emaciated because of starvation and not disease. Obviously, all the precautions to protect the consumer from meat-borne diseases should be applied when making such a concession. A further possibility is the conversion of unsaleable livestock from overstocked areas into valuable food for human consumption.

In Kenya, as in many under-developed countries, certain areas are heavily overstocked, with concomitant devastation of grass and soil, while in other areas of the country the diet of the people is grievously

PLATE II. Field Abattoir: Sun-drying of Meat

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PLATE III. Mobile Bone Meal Plant. (Note arrangement to prevent recontamination of sterilized bone meal)

deficient in animal protein. Where overstocking exists in one area, and a meat deficiency in another, the obvious approach is to de-stock the overstocked area and supply the meat to those who cannot keep enough livestock to satisfy their protein requirements. Unfortunately, such a simple solution is generally impracticable except where a suitable railway exists. Waterless stretches of country infested with tsetse fly and ticks, where cattle are subject to decimating diseases, may prevent livestock from reaching the consuming areas on the hoof. Stock movement may be restricted for many months of the year because of the need to maintain disease quarantines. Where disease is not present, healthy animals sent on the hoof to the consuming areas may well arrive in such poor condition that the proposition is uneconomic. All too often, the stockowner is only willing to sell animals which are emaciated or aged. Such stock cannot make the trek to the consumer.

A large proportion of animals on overstocked land are undersized and unfleshed. Such stock is not suitable for fresh meat, and cannot grow out on overstocked pasture. Fresh meat storage in Kenya requires refrigeration even for relatively short periods, but the high cost of refrigeration and the slow transport available with inferior road and rail services make the transport of carcases uneconomic from the distant overstocked areas.

Dehydration

The Kenya Veterinary Department has attempted to solve this problem by destocking such unproductive beasts and converting them by dehydration into valuable sources of protein and minerals for humans and animals. (Plate II.)

For eight years, two field abattoirs have been operating in the heart of the overstocked areas, namely, Baringo and Samburu. Up to now, 51,020 cattle, 15,640 camels, and 83,590 sheep/goats have been processed and converted into such products as dried meat, edible fat, suspension dried hides and skins, inedible fat, meat meal, blood meal, bone meal, liver meal and hoof and horn meal. The total weight of the products amounted to over 10,000,000 lb.

The products found a ready market and are used:

(a) to supply protein to humans unable to afford adequate fresh meat or milk;
(b) to provide animal protein for non-grazing animals such as pigs and poultry, thus, in turn, increasing the production of protein foods for humans;
(c) to produce mineral licks for cattle, thus helping to increase production of meat and milk.

The popularity of dried meat encouraged further research into the production of an alternative yielding more edible products, having better keeping qualities and being less subject to damage by wetting and insects. The result is a 'meat powder', which is a flour manufactured from the whole animal with the exception of the hide, bones, hooves, horns and the intestinal tract, enriched by the addition of concentrated bone liquor containing most of the extractives and proteins present in the bones. The analysis reveals the following data:

	per cent
Moisture . .	5—7
Fat . . .	9—11
Ash . . .	5·2—6·10
Crude protein .	72—74

The meat powder is a yellowish-brown, pleasant tasting and smelling flour with an agreeable 'cooked meat' odour and 'meat gravy' flavour which has the following advantages:

(a) Unlike dried meat, which is sun-dried but raw, meat powder is cooked.

(b) Meat powder, being packed in airtight metal containers, is impervious to attack by moulds or beetles, while, because of its low fat content, it does not become rancid. Samples kept at room temperature for four years show no sign of deterioration.

Soaking is unnecessary and the meat powder can be used as protein food by itself, or, more economically, to supplement the protein content of carbohydrate foods such as cassava, maize or other starches.

Hygienic Handling of By-Products

The aim should be to use all by-products, such as meat, bone and blood meals, as stock feed in the country of manufacture, but some underdeveloped territories, with vast quantities of desert bones or bones and offal left from canning, destocking operations, airlifts, or boneless meat production, may have a surplus for export. This surplus may also be created by the immature stage of the animal industry and perhaps by religious objections to keeping pigs.

Stock feeds and fertilizers of animal origin have long been recognized as a potential source of anthrax, and little remains to be added to the existing reports on this subject. Unfortunately, however, evidence is mounting that some consignments of by-products destined for stock feed production, such as bone meal, meat meal, blood or liver meal, although free from anthrax, are contaminated with salmonella organisms.[2] Obviously, the risk is greatest with products manufactured under tropical conditions where the environmental hygiene and the adverse climatic conditions, combined with rodent or fly infestation, may lead to contaminations even in material which has been properly sterilized.

Reports from many parts of Africa indicate that salmonellae are widely distributed not only among humans but also in lizards, cockroaches and flies, as well as livestock, poultry and pets such as cats and dogs. A survey made in Ibadan, Nigeria, led to the discovery of 290 strains of salmonellae distributed among 68 serotypes; out of these 180 strains were isolated from human sources; the remaining 110 strains were found in cattle faeces, chickens, lizards, rats, dogs, and even fish.[3] Similar reports, equally alarming, are originating in Ghana.[4] Such findings are not confined to Africa. Bone meal produced as a by-product in a gelatine factory in Australia showed not less than 91 per cent of the bone meal samples to contain salmonellae; these salmonellae survived storage in bags on farms for over two years.[5]

Resterilization and Its Effects

In view of the better understanding of the channels through which zoonoses are spread, one must ask whether the word 'sterilize', hitherto taken as fulfilling the classical demand that bone meal and other stock feed should be free from *Bacillus anthracis* and clostridia, is still sufficient, or whether complete freedom from contamination by other pathogens should be required. Several importing countries, realizing the danger to public health of introducing anthrax and salmonellae, have legislated that imported stock feed must be resterilized under their own control before being sold to stockowners in their territories. Such products are charged into a dry rendering tank and subjected to about 20 lb. pressure at a temperature of 115°C. for 45 minutes. Such treatment may have no

TABLE I

CHEMICAL ANALYSIS OF MEAT MEAL
(*ex Veterinary Field Abattoirs*)

CRUDE PROTEIN (N × 6·25) = 75·3 per cent.
MOISTURE = 8 per cent.

COMPARISON OF AMINO-ACID COMPOSITION*
(grammes per 16 grammes nitrogen)

	STANDARD PRODUCT	RESTERILIZED PRODUCT
Lysine	7·7	7·3
Histidine	3·4	2·9
Arginine	6·6	6·5
Leucine	7·0	7·6
Isoleucine	4·3	4·3
Valine	4·7	4·7
Phenylalanine	3·8	4·3
Threonine	3·9	4·1
Methionine	2·2	2·0
Cystine	1·0	0·71
Aspartic acid	8·5	8·2
Serine	3·7	3·7
Glutamic acid	14·7	14·7
Glycine	7·4	8·2
Alanine	7·0	6·9
Proline	5·2	5·5
Hydroxyproline	0·05	0·08
Tyrosine	3·0	3·2

*Chromatographic separation conducted by Tropical Products Institute.

deleterious effect on the quality of bone meal which is fed for its calcium and phosphorus content. Nevertheless, the cost of resterilization affects the price to the consumer, and in the opinion of the Report of the Committee of Inquiry on Anthrax would amount to nearly £10 per ton.[6]

The same process, when applied to stock feed such as meat meal, blood meal and carcase meal, not only raises the price but has a destructive effect on the amino acids. Several essential amino acids are vulnerable to heat when moisture is low. During resterilization, high pressure and temperature are applied to a product whose moisture content is usually below 5 per cent, and therefore the amino acids for which the stock feed is valued are affected.

If the resterilization were carried out in two phases—wet and dry—it is possible that there would be less destruction of amino acids, since the wet phase would rehydrate the product. The time taken and the need to use expensive equipment would, however, make the cost of such a dual-phase process prohibitive.

The figures given in Table I for meat meal show the difference between a product, which was subjected to dry heat resterilization at 125°C. for about one hour, and a standard product, i.e. one that was milled and sacked after dry rendering without resterilization. It is seen at a glance that, in chemical terms, the difference in the figures for the amino acids is negligible.

The figures for *available lysine* g/16gN are, for the standard product, 7·1, and, for the resterilized product 6·3, or 91 per cent for the first product and 86 for the second.* This chemical test, whilst indicating some damage done through resterilization, fails to show its full extent, which can only be proved by biological tests.

Biological Values of Meat Meal

Net Protein Utilization† N.P.U. (Standardized)	
Standard Product	Resterilized Product
57	39

†Analysis conducted by Human Nutrition Research Unit, Medical Research Council, Mill Hill, London.

This analysis clearly shows that the *biological values* of the amino acids were drastically reduced.

As both products look alike and as both, on chemical analysis, show identical nitrogen content (which in turn is interpreted by the multiplication of N × 6·25 into crude proteins) and are sold on this protein unit, the purchaser is deceived over their biological values.

The destruction of essential amino acids reminds one of the time when a strong concentration of phenol was used on superficial wounds to kill infection with complete disregard of the severe harm done to the skin itself. The public health veterinarian is obviously faced with a dramatic question: Should the salmonellae be destroyed at the cost of denaturing part of the proteins, or are the proteins of such importance that it is better

*Figures provided by T.P.I.

to raise the environmental hygiene to a standard where salmonellae contamination is unlikely, or where, if it occasionally occurred, contamination would be slight? On the other hand, one must wonder why many new strains of salmonellae were not established in Europe from the stock feed imported from many other countries, which, over the years, were obviously more infected with salmonellae than they are today (because of lower hygienic standards). Reports that samples of 18 per cent of the boneless meat landed in the United Kingdom between 1956 and 1959 were found to be contaminated with salmonellae and 10·3 per cent with heat resistant *C. welchii* are alarming.[7,8] The risk of survival of salmonellae in underdone meat, on contaminated hands, tables and utensils, in shops and food-producing establishments, is obvious. Other products, for example 18·6 per cent of samples of coconut flour from Ceylon, were found to be contaminated with salmonellae.[9] It is worthwhile noting that sanitary regulations governing imports into the United Kingdom of products other than stock feed have not been as strict. With the present great influx of students from the tropics, who may be carriers, a real danger exists that new strains of salmonellae may be introduced into Europe and the U.S.A. It is of prime importance, therefore, to establish a standard procedure representing both medical and veterinary professional opinions on what public health precautions should be taken in general and not only with regard to stock feed.

Methods of Rendering and their Disadvantages

The term 'rendering' embraces both the recovery of the fat and the sterilization of the emerging products. The resultant milled product, when offered for sale, is referred to as 'sterilized'. There are two basic methods of rendering.

(1) *Wet Rendering*

This involves the injection of live steam directly into the raw material, contained in a vertical retort, until an internal pressure of 20 lb. per sq. in. is built up. The fat floats to the top and can easily be recovered. The sterilized material is dried in large rooms at a temperature of about 100°C. and may remain there for days or weeks until it is completely dry and ready for packing. It is at this stage that reinfection is liable to occur.

(2) *Dry Rendering*

In this process the steam is not injected directly into the raw material but into the steam jacket of a horizontal retort (called a 'melter') containing the material. The moisture in the raw material itself is converted into steam which gradually builds up the internal pressure to 20 lb. per sq. in. Excess steam is discharged through a release valve. The dry rendering process is highly efficient when the raw material is wet but may be unsatisfactory when dealing with, for example, dry or desert bones containing little or no moisture to create the necessary pressure.

When, in 1954, the Kenya Veterinary Department started to operate a mobile bone meal plant, they decided to take precautions exceeding

even the recommendations of the Joint WHO/FAO Expert Group on Zoonoses.[10]

The procedure is as follows:[11,12]

The bones undergo both wet and dry sterilization and the flow of operations is uninterrupted so that there is no delay between discharging from the digester and milling. Plate III shows how the sterilized bones enter the mill and emerge in the form of flour, passing directly into the bags and onto a lorry; the coded bags are hauled immediately to a store whilst bacteriological tests are conducted. They are released only after a negative report on pathogens is received. Up to now, over six million pounds of bones have been processed, giving satisfactory bacteriological results.

Further Research and Adequate Legislation as Matters of Urgency

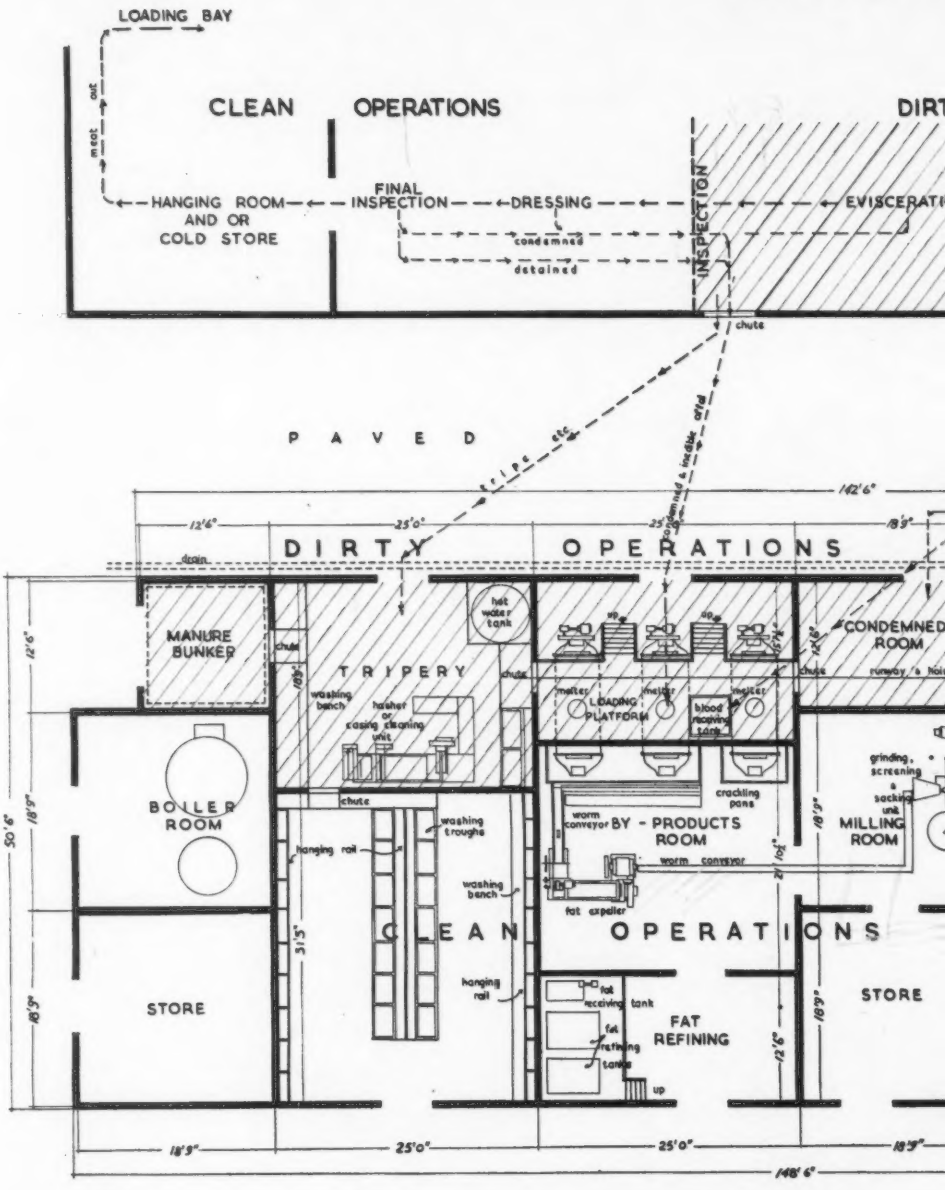
The fear of establishing new strains of salmonellae in the temperate zones through human/animal cycles by the importation of infected stock feed material is, no doubt, a real one. This problem must be faced. A certificate covering a consignment from which one or more satisfactory samples were taken may lead only to a false sense of security since samples taken from another bag, or even from the same bag but in another place, may contain salmonellae. The complex public health questions to be answered are: Will those enteric pathogens present in stock feed pass through the intestinal mucose and establish themselves in the blood or tissue of the animal? Will the animal become sick and die, or, worse, become a carrier? How high must the concentration of pathogens be to cause disease in healthy livestock? Are the exotic salmonellae spp. found in stock feed identical with those detectable in meat or do the stock feed salmonellae come from an extraneous source as an independent contaminant not playing a part in the interrelationship between human and animal health? Carefully controlled experiments are needed to find the answers. The intimate contact between man and animal in underdeveloped territories, combined with the low hygienic standards, obviously predisposes towards a man—animal—salmonellae link. As salmonellae represent a public health hazard, it is clear that the duty of veterinarians combating zoonoses is to reduce the possibility of infection in domestic animals. International legislation and control is essential, but it may not be easy to initiate and implement legislation, acceptable both to the producing and to the importing countries. Such legislation must further protect the consumer from buying products which have been resterilized and are of lowered biological value.[13,14,15]

Structural Requirements for a Modern By-Products Plant

It is now fully accepted that the slaughterhouse should be built in two distinct sections, one for the clean, the other for the dirty operation.[16] Unfortunately, this division is not applied in many by-product plants, which are considered dumping grounds for contaminated material in

A BY-PRODUCTS BUILDING AND ITS

SCALE: 1 inch = 8 fe

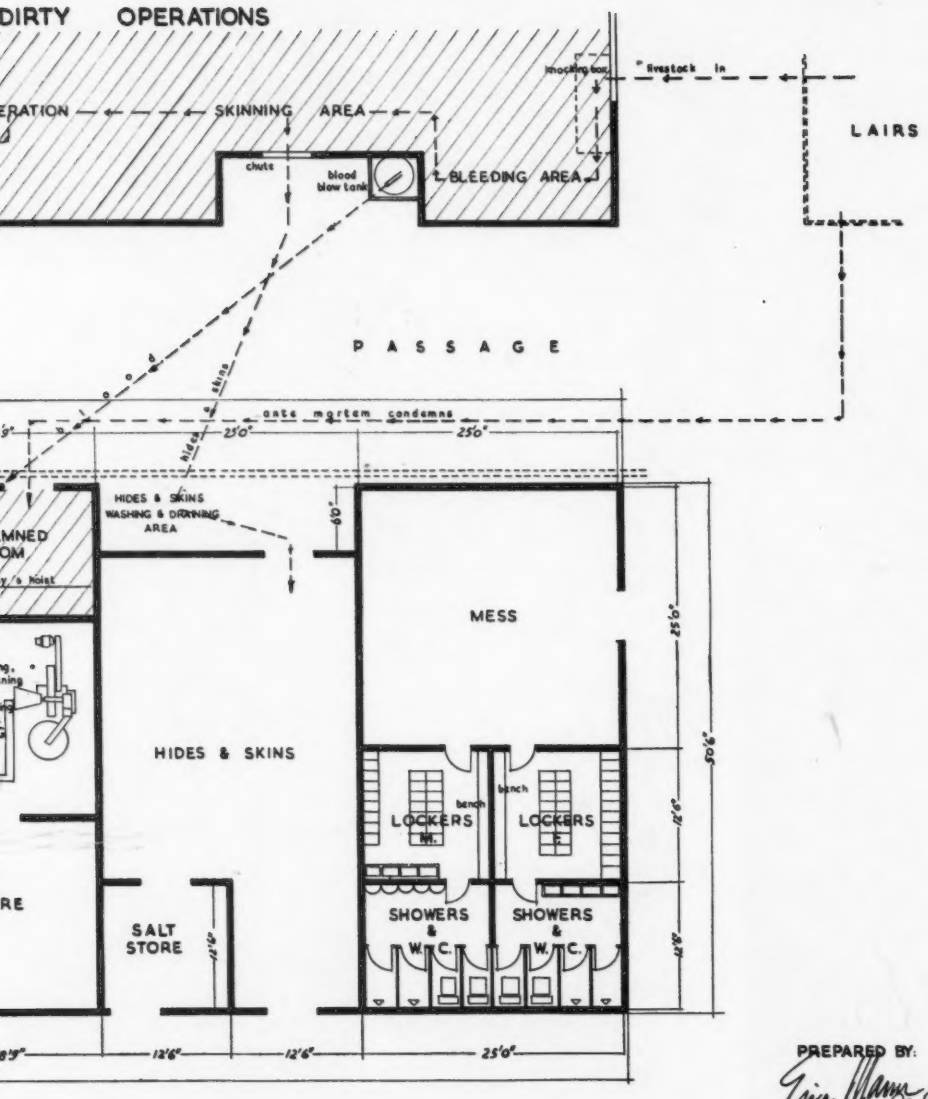


NOTE: ALL DIMENSIONS ARE FROM CENTRE TO CENTRE OF WALL IRRESPECTIVE OF THICKNESS OF WALLS

ALL 'DIRTY' AREAS SHOWN THUS:

S RELATION TO THE SLAUGHTER HOUSE.

8 feet



PREPARED BY:

order to keep the slaughterhouse clean. Officials of meat inspection services frequently fail to realize that the prompt removal of condemned carcases from the killing floor to an unsatisfactory by-product plant does not in itself finish their responsibility for controlling zoonoses. An unsupervised by-product plant may easily become a disseminating centre for zoonoses via unsterile stock feed, such contaminated stock feed infecting further animals which will ultimately enter the abattoir, thus maintaining the cycle of meat-borne disease.

Obviously, prevention is better than cure in the form of resterilization. The problem of decontamination of an improperly designed factory is often super-human, since it is known that even the dust present in the factory atmosphere may contain innumerable species of salmonellae.

It is imperative that the by-product plant should not only have high sanitary and hygienic standards but, like the slaughterhouse, should be divided into 'clean' and 'dirty' sections. (In theory, a similar division exists in hospitals, where infectious diseases are entirely separated from the general hospital.) This method is illustrated in Fig. 2 which shows that:

(1) There is no contact between the slaughterhouses and the by-product plant, except for the chutes carrying the by-products or condemned material.

(2) The rendering department is so arranged that the charging platform for the raw material is in the 'unclean' section, whilst the sterilized products emerge through a discharging door into the 'clean' part of the building. A dividing wall built across the melter ensures that there is no communication whatsoever between the two sections.

(3) The various pieces of equipment for rendering, fat extraction and milling are so chosen for size as to provide a continuous, uninterrupted flow of operations between each individual piece of equipment without exposing the material to air contamination. Wherever possible, a covered screw conveyor carries the material from one point of processing to the next.

(4) To avoid errors arising from neglect or from a fall of pressure in the boiler, the rendering vessels are equipped with automatic recorders showing time, temperature and pressure.

(5) By-product plants which are to process 'desert' bones must be equipped for both wet and dry sterilization.

(6) The staff employed in the by-product plant have their own amenities and do not come into contact with the slaughterhouse in any way.

Such a layout minimizes the risk of building up pathogenic flora in the abattoir itself and prevents the sterilized product, manufactured by the by-product plant, from contamination, thus giving a very high margin of safety.

Only those by-product plants which have been inspected and found to fulfil the recommendations in paras. 1 to 6 should be allowed to export.

It would be at the discretion of the local director of veterinary services to decide whether the products of plants not satisfying the recommendations are fit for stock feed within the country of origin or whether they should be used as fertilizers only.

Jute, sisal or other vegetable fibre bags are porous and leave the contents easily accessible to rats, mice, cockroaches, flies and hide beetles, and to contamination by their excreta. Metal containers would, of course, be the best form of packing, but would be too expensive. A polythene bag lining a standard jute or sisal bag would give cheap but excellent protection; so would multi-walled 'cement' bags.

A well-designed abattoir, supported by a properly laid-out by-products plant, is not the complete answer in combating the public health problems posed, but it materially contributes towards minimizing the spread of meat-borne disease.

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The Palm Oil Industry*

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Summary

The history of the palm oil industry is described and an account is given of the efforts to increase the quantity and quality of the palm oil manufactured overseas. The effect of climate on the nature of palm fruit and changes occurring during its development after fertilization are reported. Recent work on the improvement of the bleachability of the oil and on the minimization of lipolysis during its preparation and storage is also described.

The winning of palm oil dates back to ancient times. A large jar of fat, found in a tomb at Abydos[1] suggests that there may have been trade in the oil some 3,000 years B.C. The palm tree was mentioned by Portuguese writers—some of the first visitors to Africa—in 1446[2] and, in 1589[3], James Welsh found 'a good store' of soap smelling like 'beaten violets' at Benin. This was no doubt made from bleached palm oil perfumed with oxidized carotenoids. Other early uses of the oil were medical and culinary and a recommendation that it should be applied 'to relax stiffened nerves' and 'appease gouty pains'[4] still represents practice in Africa.

One of the first accurate descriptions of the tree was given by Bauhin in 1650.[5] He mentioned that the fruit is usually heaped together after harvesting and is afterwards crushed to yield a pleasant, sweet-smelling limpid oily liquid of a deep-golden colour. Hans Sloane in 1696[7] noted that the palm was to be found in Jamaica and in 1763 Jacquin[6] gave one of the earliest coloured illustrations of the tree.

The palm oil trade with Europe must have begun early in the eighteenth century and, in 1790, 2,599 cwt. were imported into the United Kingdom. Exports of the kernels from Nigeria may have started in 1849 and some of the first consignments were made by M. A. Mackenzie-Smith and C. Lane of Liverpool. By the middle of the nineteenth century the palm oil trade was well established,[8] so much so, that in 1856, Seeman[9] could write: 'At last a ray of hope seems to glimmer, at least for Western Africa. A production scattered over that country with a bountiful hand has been found . . . the African Oil Palm . . . but it did not assume that importance which it now claims until the introduction of new processes for manufacturing stearic candles from it . . . By this and similar processes, trade in palm oil employs no less than 20,000 tons of shipping from Liverpool alone.'

*Substance of a Paper Read at Liverpool on February 16 to the Society of Chemical Industry.

World trade in palm oil (Fig. 1) is now some 600,000 tons annually, of which about 200,000 tons come from West Africa. World production of oil, much of which is used in Africa, must be considerably higher since world exports of kernels total almost a million tons.[10]

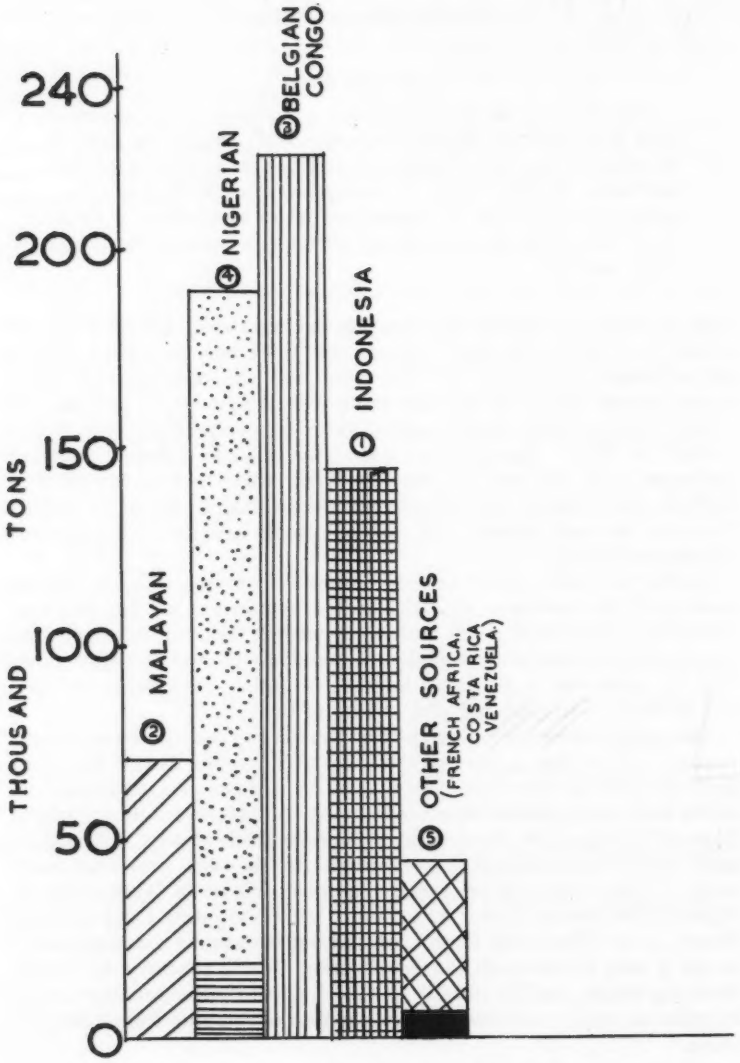

FIG. 1. World Commercial Production of Palm Oil, 1958

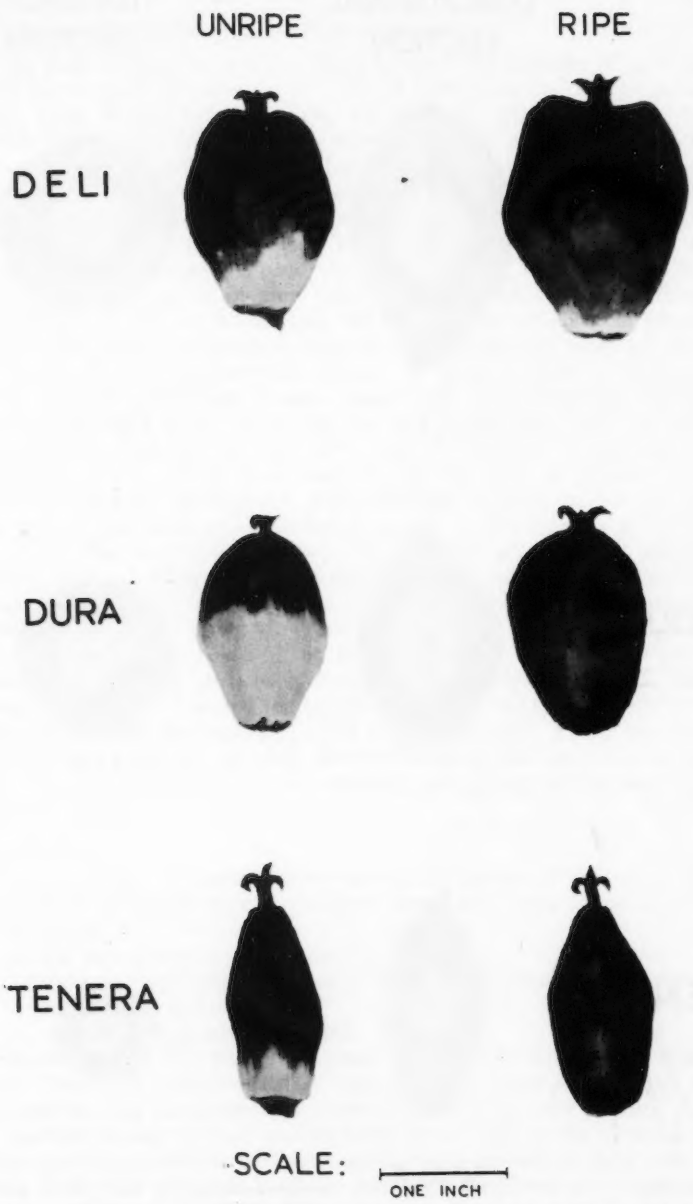

PLATE I. Fruits of Deli and African *dura* and *tenera* palms, shown both in the ripe and unripe state

(Reproduced from J. W. Afr. Inst. Oil Palm Res., 1955, No. 3)

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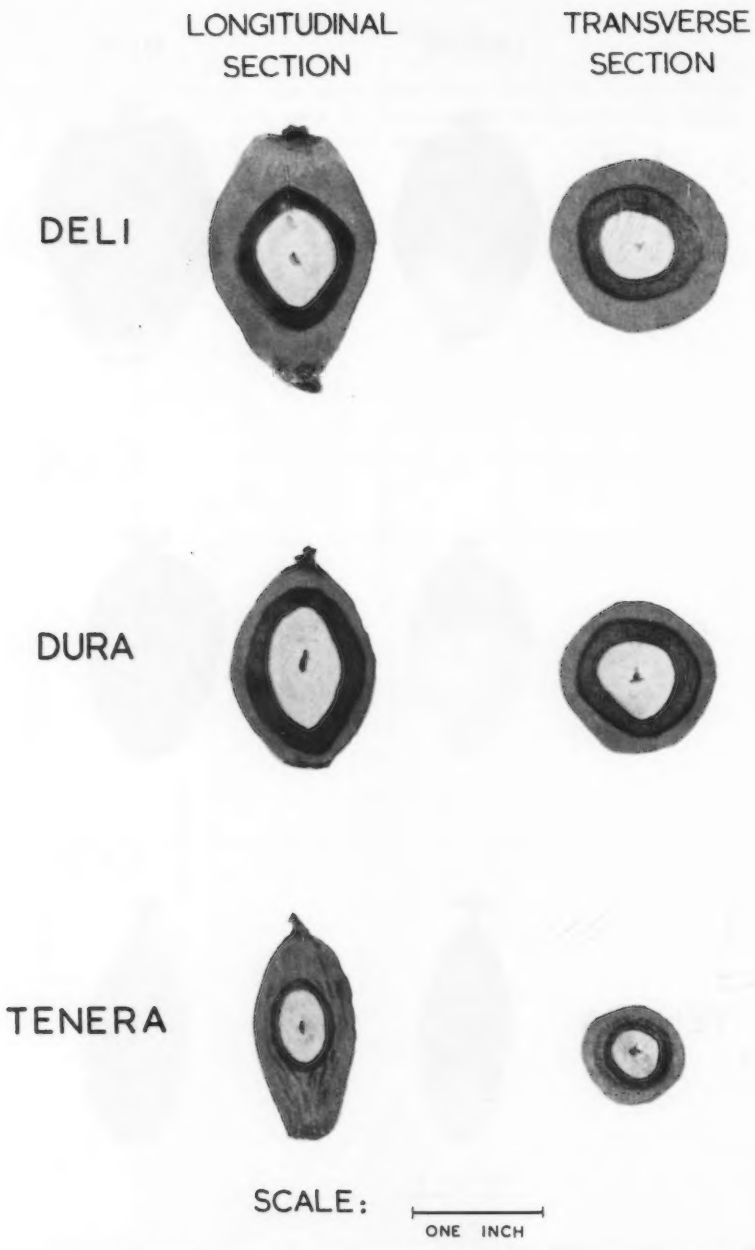

PLATE II. Fruits of Deli and African *dura* and *tenera* palms, as seen in longitudinal and transverse section

(*Reproduced from J. W. Afr. Inst. Oil Palm Res., 1955, No. 3*)

Geographical Distribution of the Oil Palm in Africa

The palm is found in tropical Africa between the latitudes of 15°N to 10°S but is most abundant in the coastal belt about 100 to 150 miles deep from Sierra Leone to the Cameroons. *Elaeis guineensis*, in Africa[11,12,13,14] is a feathery palm, some 60 ft. high and carrying a tuft of 20 to 25 leaves on its crown. These leaves are each 8 to 14 ft. long, built up of a number of leaflets 14 to 18 in. long and arranged on both sides of the midrib. The almost cylindrical stem varies in diameter, but is frequently about 24 in. across. The leaves are usually produced in whorls of three, two whorls being produced in about 18 months. In the early stages the stem is covered with bent-over dead leaves, but these later break off, leaving behind only the leaf bases on which other plants often grow. When the palm is about 20 ft. high the leaf bases fall. An oil palm starts to produce male flowers in bunches when it is about three years old and female flowers a year or two later. Male and female flowers are borne on the same tree, but not on the same stalk and are not usually mature at the same time. Several thousand flowers will be produced on a bunch, of which some 60 per cent may be fertilized and between 200-2,000 develop into fruit; the fruit is borne on bunches in the axils of the leaves and each bunch usually weighs from 10 to 50 lb. or more. The fruit itself is shaped somewhat like an olive and weighs from 3 to 20 g. At maturity its colour varies according to the variety, from almost white (albescens), to almost black (nigrescens). Between these extremes, some fruits are green (virescens) but most are orange to red. The fruit is composed of the skin (termed the exocarp), the pulp (mesocarp), together often referred to as the pericarp and the nut. The latter consists of the kernel (endosperm) and the embryo covered by a skin (testa) both enclosed in a hard shell (endocarp). Fibres are also found running through the pulp, often in the form of a ring, close to the nut. The oil is obtained from the mesocarp and palm kernel oil from the crushed kernels.

Classification

Many systems of classification have been proposed[15,16,17] but for commercial purposes we can consider three main types based on the kind of fruit,

(*a*) the *dura* type with a thick shell
(*b*) the *tenera* type with a comparatively thin shell and a ring of fibres surrounding the nut, and
(*c*) the *pisifera* type without a shell.

Reference should also be made to *macrocarya*, a fruit with a very thick shell. There are some reasons for considering *dura* and *pisifera* types as two species, but the distinction between them is not very precise. The proportion of pulp is often greater in the *tenera* than in the *dura* kinds, although it is possible to have a relatively large amount of pulp with a thick shell. The *deli* fruit is of the *dura* type associated with Malaya, which contains a relatively large proportion of pulp to kernels and the 'dumpy' palm is a selection made from the *deli* palm and, as its name indicates, is shorter than the usual oil palm (Plates I and II).

Other methods of classification take into account such characteristics as foliage, colour and the presence or absence of mantles on the fruit. Apart perhaps from colour, however, these properties are of less importance in industry. In South America another species of oil palm is found, usually named *Elaeis melanococca* (syn. *Corozo oleifera*). Although it has not been developed commercially, it is used as a source of oil by the local inhabitants and occasionally its kernels are crushed. Its short, frequently prostrate, trunk may prove useful in further plant breeding.[17,18]

Certain types of West African palms with unusual foliage are regarded as sacred or fetish palms by the inhabitants and the nuts from these palms may show more than the normal three eyes or pores. The oil from these palms is often retained for medicinal use and their kernels used for divination.

The amount of fruit in a bunch varies but is usually from half to two-thirds of the weight of the bunch. The relative amounts of shell, pulp and kernel also vary. The proportion of shell depends mainly upon the type, from 40 to 60 per cent in *macrocarya*, 20 to 40 per cent in *dura*, 5 to 20 per cent in *tenera* and usually about 30 per cent in *deli*. The *pisifera* trees are shell-less but this palm usually aborts. There is less variation in the kernel content of the different kinds of fruit which is usually about 10 (say 8 to 12) per cent. A thick-shelled nut may be surrounded by a relatively large amount of mesocarp, as in the case of the high-yielding *deli* variety, or the proportion of surrounding pulp may be almost negligible, as is often found in the palms growing almost wild in West Africa. The proportion of oil in the pulp is usually from 45 to 50 per cent and in addition, the pulp contains some 20 to 25 per cent of fibrous matter and about 25 per cent of water. It is evident that this variability, though making scientific studies of palm oil difficult, is a favourable factor for improvement by plant breeding.

Original Habitats and Development of Early Palmeries

The origin of the oil palm is still somewhat controversial. For many years O. F. Cook[19,20] has championed America, perhaps Brazil, as its home, although his arguments do not carry great conviction. On the other hand, the French botanist, Chevalier[21] and others, favour an African origin. Certainly, whatever its origin, the oil palm is now well established in West Africa and appears to have existed there from a very early period. It may have had its origin near the Gulf of Guinea before the drifting apart of the Continents and in this way passed to Africa and America.

Man has been one of the main factors in the distribution of the palm and J. M. Waterston[22] considers the fresh water swamp may have been its original habitat. He has observed several cases of the palm singularly free from disease flourishing in stagnant water. Fruit from these swamp palms is regularly harvested and man may have carried them thence to homesteads and farmsteads. Palms growing near homesteads are protected from fire and therefore have an advantage over those growing in the more isolated farmsteads. Waterston considers that the dense grove palms, which are so characteristic of the main oil belt in Nigeria, are

derived from homestead palms where the soil fertility around the home has been conserved and enhanced. These homestead or compound palms eventually develop into grove palms when the compounds are abandoned. (Fig. 2.)

The chief diseases of the palm in Nigeria are nutritional and perhaps the most common is Necrotic Leaf Spot, sometimes known as 'Bronzing' or 'Orange Spot' disease. It is associated with a potash deficiency and is not found in the fresh water homestead and compound palms, but is

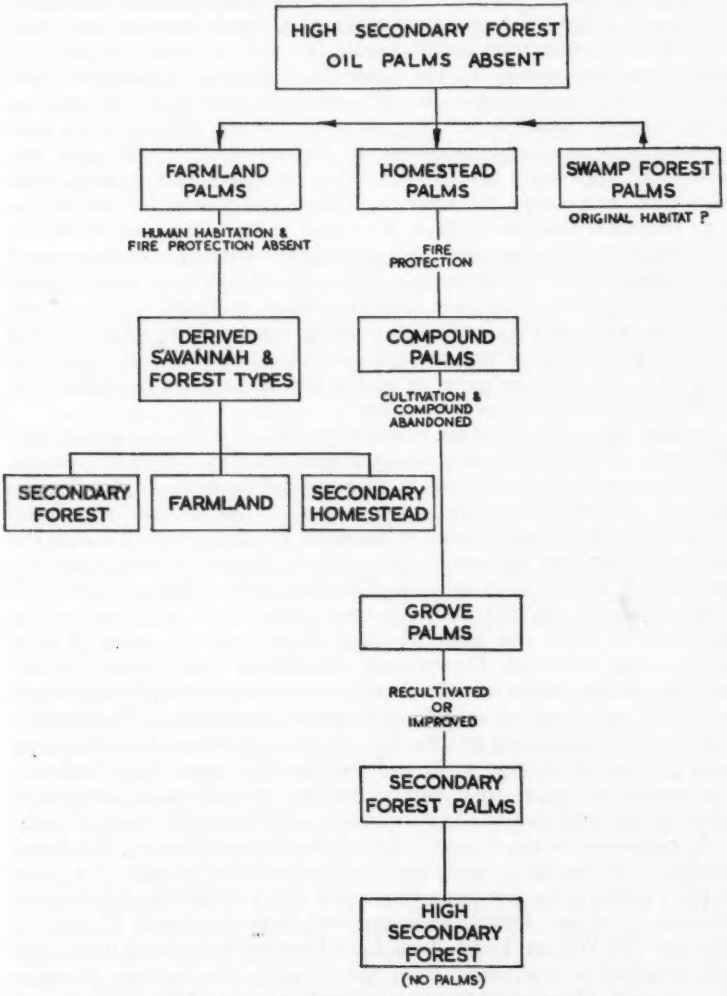

FIG. 2. Oil Palm Habitats with Relation to Biotic Factors
(After J. M. Waterston, *J. W. Afr. Inst. Oil Palm Res.*, 1953, **1**, 78)

quite severe in farmstead and plantation crops. Chief among the fungoid parasites of the palm are various rots and wilts, which again cause the greatest damage in plantations. The apparent freedom from disease of the native wild trees, as compared with plantation trees, has been referred to by many writers[23,24,25,26] and this fact is enshrined in proverbs, such as the Ghanaian 'Should all trees wither, the oil palm will still remain.'[27]

Plantations

Oil palm plantations are of comparatively recent origin. In Nigeria there were a few trial plantings made at Calabar in 1912 and 1916, followed by commercial developments in 1928 on land granted as a government concession. In the Cameroons, German plantations were started some two decades earlier. However, the bulk of the oil exported from Nigeria, some 90 per cent, is produced by Africans from trees growing in a semi-wild condition. In Indonesia[28,29,30] the palm was introduced apparently first in 1848, when two trees were received from Mauritius (or possibly the Réunion Island) and planted in the Buitenzorg Botanical Gardens in Java. The trees at that time were at least a year old and two further trees, probably of the same origin, were received from Amsterdam soon afterwards. The deli oil palms in the Far East have all originated from these four trees which provided seed for distribution as early as 1853 and were growing vigorously in 1858. In 1858 some 17 acres were planted in Java but this experiment was stopped in 1864 although the tree grew as well if not better than in Africa and started to bear fruit in its fourth year.

Despite the success of these experiments the oil palm was not at once developed commercially and, for some time, the nuts obtained from the trees were used for paving roads. Commercial development in the Far East was undertaken by a Belgian firm in 1911 and, in four years, 6,500 acres of palm had been planted in Sumatra. Planting stopped during the first world war but the area under palm in Sumatra's East coast had increased to 28,000 acres by 1922. The bulk of the Malayan trees[31,32] were, seemingly, derived from the same stock. Some seed was sent to Singapore in 1870 and again in 1875, when seed was received from Ceylon and, although Government plantations were started around 1902, the earliest commercial development was independent of the Government and was based on seed from Sumatra. According to Fauconnier, a pioneer, Tennamaram was the first estate in Malaya where oil palms were planted on a large scale and seed for this came from Sumatra. Apparently, as late as 1952, two of the four original palms introduced into Java were still standing in good health and were said to be 70 ft. high.

Developments in the Congo[33] have been rather different. The introduction of the tree there must have coincided with the immigration of the Bantu, possibly some 400 years ago, but it was not until 1910 that small amounts of oil and kernels were exported from the Lower Congo. In that year, Sir William Lever (later Lord Leverhulme) visited the Congo and obtained a concession from the Belgian Government covering 750,000 acres. He selected five points for the erection of factories and, at first, these were solely concerned with processing fruit purchased from

the African. Later the Unilever concern fostered the development of plantations there.

The oil palm also grows well in the Western hemisphere[34] and was probably introduced into Jamaica before 1688. It also grows in other parts of the West Indies, Martinique, Trinidad, Puerto Rico, and elsewhere. In Haiti it is an important subsistence crop and in South America the palm has been introduced into Brazil, Venezuela, Colombia, British Guiana and Peru. The next large expansion of oil palm production may well come from this hemisphere, since some of the trees have spread in a wild state, and the others are in plantations which are now beginning to bear fruit.

There are also some oil palms which grow wild in Madagascar but according to some authorities these should be regarded as a separate species, *Elaeis madagascarensis*. The variation in the characteristics of the fruit from various palms can cause considerable difficulty in identification and specific differentiation.

Oil Yield

Sir Harold Tempany[35] has compared the potential oil yield from various crops and placed the oil palm at the head of the list with an annual yield of 1,397 lb. per acre, of which 1,250 lb. comes from the pulp (mesocarp). This yield can be compared with the 904 lb. per acre from the coconut, and 336 lb. per acre from the groundnut. Under favourable conditions, the yield of the oil palm can be increased up to as much as two tons per acre.

It is evident that, by improving the present palmeries and extending others, world supplies of palm oil from this source could be considerably increased. In the African forest, where the oil palm grows wild, the palm begins to fruit after about 10 years and does not give a full crop for about 20 years. However, when the palmeries are cleared much larger yields are obtained. In one instance the average yield from wild palms increased from 6½ lb. of palm oil and 6½ lb. of kernels to 15 lb. of oil and 11 lb. of kernels per tree. In South-east Asia the oil palm plantations give about 30 to 45 lb. of oil and 10 lb. of kernels per tree.

Processing the Oil

Palm oil is manufactured from the fruit by a variety of procedures with various types of apparatus; some of the earliest African methods fall into two broad classes. First, there are processes which involve sterilizing the fruit and then pressing out the oil. This gives the so-called 'soft' oils of low acidity. A second group of processes involves fermentation. The moist fruit is left for a day or even much longer, after which most of the oil may run out naturally by gravity and a further quantity is obtained by processing with hot water. This oil is termed hard and may contain 50 per cent or more of acid and, as late as 1922, the three grades recognized by one United Kingdom contract were from 25 to 40 per cent acidity, 45 to 60 per cent acidity and over 60 per cent free fatty acids. At an early stage in the development of the African industry the use of machinery was recommended for the production of a soft oil, although

there was perhaps less interest in this oil before the first world war when the main outlets in European trade were to the soap, candle and tin-plate industries.

The cause of the difference between hard and soft oils was recognized at an early date. Fickendey[36] in 1910 clearly stated that high acidity was the main obstacle preventing the use of palm oil in margarine and other edible fats. He showed that the sterilized fruit was capable of yielding an oil with an acid value as low as 5·3, as compared with the 94·5 obtained for parallel experiments with unsterilized fruit. He attributed the development of acidity to the presence of a fat-splitting enzyme and also mentioned that acidity could develop in the oil due to infection with and subsequent growth of micro-organisms in the sterilized fruit flesh. Oil which was protected from damage from these two sources did not appreciably increase in acidity and he therefore postulated three steps to improve the quality of the oil:

(1) the selection of ripe fruit for processing
(2) the sterilization of the fruit to inactivate the fat-splitting enzymes
(3) the processing of the fruit as rapidly as possible.

Detailed descriptions of the methods found in operation in West Africa at the start of this century are given by Faulkner and Lewin[37,38], and Adam[11], Gray[39] and Barnes[40,41]. Highest yields were, in general, obtained by the hard oil process which gave usually about 10 per cent, compared with 7 or 8 per cent obtained by the soft oil process from perhaps some 20 per cent of oil in the fruit. Barnes devised processes yielding soft oils, giving higher yield, from 9 to 11½ per cent, according to the variety of fruit.

The development of the history of oil seed milling in Europe has been largely the development of machinery capable of exerting increased pressure, and a great step forward was made with the invention of Bramah's hydraulic press.[42]

Some idea of the progress made in improving quality since 1910 may be gauged from the proportion of Special Grade Oil (containing 5 or less per cent of acid calculated as palmitic acid) in the total shipments from Nigeria for selected years. In 1950 the proportion was 0·2 per cent, in 1952, 29·6 per cent, and, in 1960, over 81 per cent. This improvement in quality is due to improved methods of processing and hand-in-hand with improved quality has gone improved efficiency of extraction. This followed a demand for increased supplies of better-quality palm oil for export.

The present methods of processing[45] may perhaps be divided into steps as follows:

(1) *Harvesting the fruit*

The fruit is collected either by hand or on Estate trucks. If collected by hand it may wait several days on the bunch at the roadside before it is processed.

(2) *Removing the fruit from the bunch*

On plantations, trucks loaded with bunches of fruit may run straight into a horizontal sterilizer. Alternatively, the bunches may

be damped with water to facilitate retting the fibre which joins the fruit to the bunch. The fruit can later be removed by hand or mechanically.

(3) *Sterilization*

The fruit is either treated with steam or boiled in water. The enzymes responsible for the deterioration of the oil are destroyed at about 70°C and the time taken to sterilize the fruit depends to some extent on its ripeness. When boiling water is used it is safe to allow an hour's sterilization, but when steam is used on stripped fruits, 15-20 minutes at 20 lb./sq. in. is adequate (Pioneer Oil Mill). If sterilization of the bunches is carried out before stripping (normal plantation practice) higher steam pressures are generally used viz.: 30 to 40 lb./sq. in. With high pressure steam (plantation practice) for example exceeding 28 lb. per sq. in., processing for more than $\frac{3}{4}$ h. generally causes some browning of the palm kernels. This discolouration of kernels which leads to trade discounts can also be caused by bad storage. In this connection some recent work by the West African Stored Products Research Unit may be consulted.[46]

(4) *Digestion*

This process consists simply of stirring the sterilized fruit whilst maintaining it at a high enough temperature to permit efficient oil extraction as soon as the digestion is complete. Its purpose is to render the mass homogeneous, to detach the pulp from the nuts and facilitate the subsequent removal of the kernel. Recent studies have shown that carefully controlled digestion is an important factor in efficient oil recovery.[47]

(5) *Recovering the Oil*

This may be done by using centrifuges or by expression. The pressure applied may be discontinuous, as in the cage press, or continuous, as in screw presses. Solvent extraction and water displacement are not often applied in modern palm fruit processing. It is generally considered that presses will recover more oil than centrifuges, but the selection of any particular extraction process must be based partly on the nature of the fruit to be processed, and partly on other factors which enter into the planning of the whole factory. Centrifuges have been adopted for the Pioneer Oil Mills which have been designed for co-operative use but discontinuous presses are used in all plantation factories in Nigeria. Discontinuous presses, continuous presses and centrifuges are used elsewhere.

(6) *Clarification*

The oil obtained from the centrifuges is usually cleaner than that obtained from the presses but both require some degree of purification. This may involve using high speed centrifuges as well as batch or continuous settling processes. In Nigeria, the African processed oil is usually further cleaned in the bulk oil plant which sieves and washes it and separates it in a centrifuge.

Several primitive methods of processing the fruit are currently employed in Nigeria including pounding in a primitive mortar, trampling

in canoes, squeezing out by hand and water displacement but there is a tendency for these methods to be replaced by hand presses. The hand press will usually treat about 1¼ cwt. of fruit at one time and has an output of from 150-250 tons oil per annum of 250 working days. Whereas only 40 to 55 per cent of the total oil contained in the fruit can be recovered by the more primitive methods, the hand presses usually operate at not much less than 65 per cent efficiency and some workers claim they can be operated at much higher efficiencies (if double pressing is carried out). More recently[47] a hydraulic press suitable for small-scale operation has been developed and the calculated efficiency from the oil to dry fibre ratio attained in experimental peasant extraction was around 90 per cent. The Pioneer Oil Mill, which was introduced to provide a small modern processing unit for use by Co-operatives, deals with about 4½ tons of stripped fruit per day in one shift and consists of matched processing units for winning the oil, with a separate boiler fired by the waste fibre and shells. A larger 'Major Pioneer Oil Mill' incorporates a fruit stripper. An efficiency of 85 per cent is claimed for the Pioneer Oil Mill. The usual plantation mill is somewhat similar to the Pioneer Oil Mill, except that it makes use of presses and of bunch sterilization and bunch stripping techniques, and usually operates at a recovery efficiency of 90 per cent or more. Some idea of the progress attained in peasant mechanization in Nigeria over the past decade can be obtained from the following figures[48] which show the proportion of the total oil production obtained by different methods in 1950 and in 1960:

	1950	1960
	per cent	*per cent*
Primitive . . .	92·2	25-30
Hand presses . .	6·7	65*
Pioneer Mills . .	1·1	5-10

* From information published by the U.S. Dep. Agric. 1959.

Quality

Samples collected in Nigeria in 1960 from various production units gave the following figures on analysis:

	Peasant Production		*Plantation Mills*
	Manual presses	*Pioneer Oil Mills*	
Acidity per cent calculated as palmitic acid	3·3 to 5·3	3·1 to 4·2	1·7 to 4·2
Absorption $E^{1\%}_{1\ cm.}$ 230 m.	1·4 to 2·0	1·8 to 2·4	2·1 to 3·3
Peroxide value (ml. 0·002N. $Na_2S_2O_3$/g. oil)	0 to 0·4	0 to 1·4	0·4 to 7·0
Iron p.p.m.	6–18	4–6	3–10
Earth bleachability residual colour* . .	37–118	26–100	30–102

* In Lovibond units (10 × R + Y) in 1 in. cell.

Bleachability

The term 'earth bleachability' requires some explanation. Since 1900 the demand for palm oil from the soap and candle industries has fallen sharply, but more oil has been used by the edible trade. For this trade an oil of low acidity and good bleachability is essential but the methods

of bleaching acceptable to the edible trade are less violent than those used for bleaching oil for candles and soap. Some of the oil used by the edible trade in the United Kingdom is bleached by earth, but some is bleached by the use of special heat processes. However, experience has shown that the Nigerian oil is inferior in its bleachability to oil from the Far East and this difference has resulted in Nigerian oils suffering a discount on the market, often about 30*s*. per ton. Since this loss amounts to a considerable sum over a year the Nigerian Produce Marketing Co. asked the Tropical Products Institute to investigate the causes of the difference. One of the first steps in this investigation was to standardize methods of bleaching and three types of bleaching tests were elaborated.[49] In one the oil was stirred at 105°C for one hour with 5 per cent (by weight) of a special type of Fulmont Fullers' earth. In the second test the oil was heated under nitrogen at 230°C for 30 minutes, and the third test involved a combination of heat and earth bleaching. In the earth bleaching test, the residual colour range of 37-118 for 21 samples of Nigerian palm oil compares with a range of 14-24 in similar tests for Malayan oil, whilst the figure for Sumatran oil is usually about 15.

Possible causes of this difficulty in bleaching Nigerian oil were thought to be:

(*a*) The type of fruit grown in Nigeria. In general this yields a dark-coloured oil. Mention has already been made of the *deli* fruit, commonly grown in Malaya and the Far East, which, although originally introduced from Africa, consistently produces an oil which is much lighter than the Nigerian oil.

(*b*) Differences in climate. The differences between Malaya and Nigeria are not very marked but may be important and are known to influence the nature of the oil in ways other than bleachability.

(*c*) Differences of the soil in which the tree is grown. This could be a factor influencing the bleachability, or, more probably, there could be a combined effect of soil and climate.

(*d*) Different processing methods. Whereas the bulk of the Nigerian oil is prepared by peasant methods almost all the fruit in the Far East is treated in large plantation factories. However, some of the Nigerian oil is produced in plantation mills which do not differ very appreciably from those in Malaya, and some Nigerian plantation oil is just as difficult to bleach as peasant-produced oil.

So far as climatic and regional influences are concerned, it is now known that the composition of palm oil—including the colouring matter—varies according to the locality in which the palms are grown. Different methods of processing may also affect bleachability and the T.P.I. investigations showed that it is important not to bruise the fruit, to process it without delay and to avoid heating, oxidation and contamination with iron.

Varietal and Climatic Effects on Palm Oil Composition

The colouring matter present in palm oil is almost entirely carotenoids. About 65 per cent of these are β-carotene, about 20 per cent α-carotene and 15 per cent lycopene. The gross amount of colouring matter varies

widely in the oil from different types of fruit, being 100 parts per million (calculated as β-carotene) or less in the oil from albescens fruit, and 2,500 parts per million or more in that from dark-coloured fruit. Most Nigerian oil contains from 300 to 2,000 parts per million, being usually in the range of 1,000 and 1,300. The oil from *dura* fruit is generally more deeply pigmented than that from *tenera* palms.

Recent studies carried out by l'Institut de Recherches pour les Huiles et Oléagineux, Paris,[50] show that prolonged periods at 20°C do not favour colour development and that dry heat, little rain and much sunshine produce darker pigmentation. Most of the oil from the Cameroons is less pigmented than Eastern Nigerian oil. During processing in Africa and subsequent transit to Europe some carotene is lost, but under favourable conditions, this is slight.

The oil consists mainly of glycerides, some 30 to 50 mol. per cent of palmitodiolein, some 30 to 50 mol. per cent of di-saturated glycerides and about 10 mol. per cent of linoleodiolein. Professor Hilditch and his co-workers[51] have studied the constituents of palm oil obtained from different regions. They have found that the two major acids, palmitic and oleic, usually total about 80 per cent of the fatty acids, but that their relative proportions vary according to locality. Plantation palms usually yield an oil containing significantly more palmitic acid than that from wild palms. Evidently the composition of palm oil is affected by the conditions under which the tree is grown but broadly it may be said that the fatty acids present consist of about 40 per cent of palmitic acid, about the same amount of oleic acid, some 10 per cent of linoleic acid and small amounts of stearic and myristic acids.

The development of fat in the fruit itself during growth has been studied by Mary Crombie and Hardman.[52] The immature pulp contains

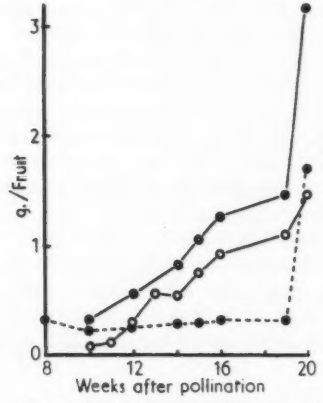

FIG. 3. Comparison of the development of kernel and mesocarp (dry weights)

●——● Whole fruit
○——○ Kernel
●- - -● Mesocarp

(Courtesy: J. exp. Bot., 1958, No. 9)

only a low proportion of fat—about 1 per cent of its dry weight—with a quite different composition from that which appears after a rapid change 19 to 20 weeks after pollination. In the early stages the major components of the very small amount of fat are palmitic and linoleic acids but, at 20 weeks, the fat forms more than 50 per cent and sometimes over 70 per cent of the dry weight of the mesocarp, when it has as its normal major components palmitic and oleic acids.

The dry weight of the mesocarp is more or less constant from the eighth to the nineteenth week after pollination but it increases several-fold in the following week. This behaviour contrasts with the development of the dry weight in the kernel itself (Fig. 3).

Effects of Different Methods of Processing

Preliminary studies at T.P.I. of the variation in the composition of oil from different processing sources in Nigeria showed that those oils in general which had a high absorption at around 230 mμ were harder to bleach. Since the absorption at this wavelength is associated with the presence of conjugated dienes resulting from the oxidation of linoleic acid it was tentatively concluded that oxidation during processing was a major factor causing inferior bleachability. Samples of virgin oil from Nigeria were therefore prepared experimentally with great care and were found to have excellent bleachability, yielding residual colours usually between 3 and 10 (i.e. lighter in colour than bleached Far Eastern oil). The samples were heated to about 105°C and a current of air passed over them for about an hour. They became difficult to bleach only when iron (in the form of iron palmitate) was added. Samples of Nigerian oil collected from native producers often had poor bleachability even though iron content was low and it was therefore concluded that bleachability had been adversely affected at an earlier stage of processing.

The factor which seemed most likely to affect bleachability at an early stage in processing was enzymic oxidation following bruising of the fruit and delays in processing it. Tests were therefore carried out on samples which were carefully prepared but left for varying periods before processing. There was found to be a steady deterioration in bleachability the longer the processing of the fruit was delayed. The results of the experiments were not entirely consistent but this was probably due to the difficulty in obtaining exactly similar types of fruit (Fig. 4).

Samples of ripe and unripe fruit were then sent to the Institute packed in charcoal and assayed for lipoxidase activity. The enzyme lipoxidase which is detected in a wide range of vegetable material is known to affect the coupled oxidation of carotenoids and unsaturated fatty acids. In each of nine experiments the mesocarp of a single palm fruit was defatted and the extract examined for lipoxidase activity according to Holman's[53] procedure. Values of 1·9 to 10·1 units of lipoxidase activity per g. were observed for individual ripe and unripe fruits. To determine the effects of oxidation with lipoxidase on the bleachability of palm oil, experiments were conducted similar to those described by Koch[54] and others in 1959 in connection with work on the oxidation of cotton seed oil. Coarsely

ground haricot beans (used as a convenient source of lipoxidase) suspended in water, were mixed with easily bleached palm oil and homogenized at 30°C for about ten minutes. The whole was then centrifuged and some 60 to 70 per cent of the oil recovered. The carotene content, peroxide value, extinction coefficient at 230 mμ and bleachability were then re-determined for the oxidized oil and compared with the corresponding values for the original oil. These experiments all showed that,

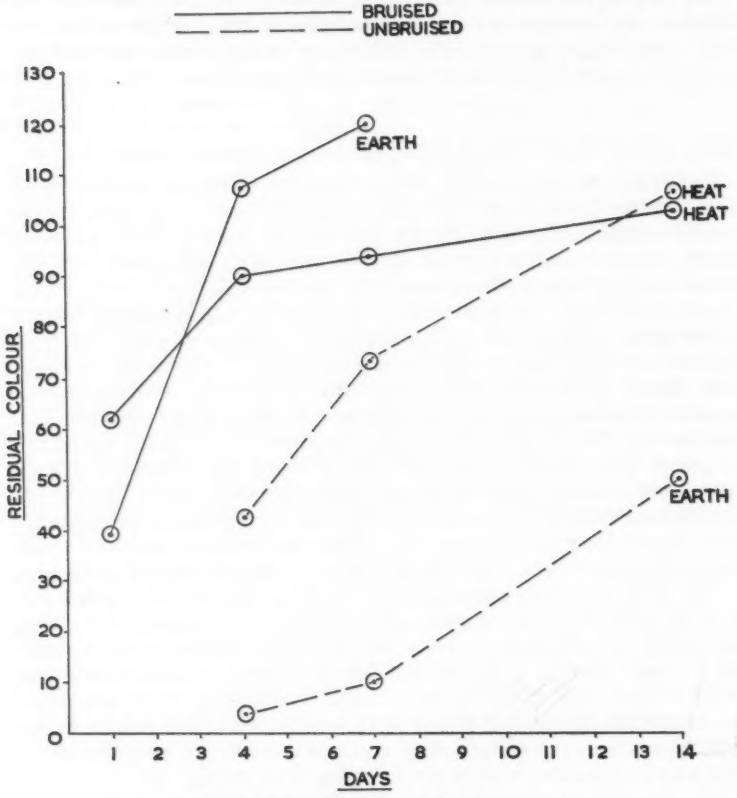

FIG. 4. Bleachability—Deli Krater
(Carotene, 400–1,300 p.p.m.)

as with catalytic oxidation, enzymic oxidation causes a marked deterioration in the bleachability of palm oil. In order to confirm that lipoxidase activity detected in palm fruit was capable of oxidizing palm oil, an experiment was conducted using defatted palm fruit mesocarp instead of haricot beans and a considerable deterioration in bleachability was observed. On the basis of the lipoxidase assay of palm fruit mesocarp, the activity of the extract used in this experiment would be approximately one-fifth of that of the haricot bean extract. The theory that the poor

bleachability of Nigerian peasant produced oil is due mainly to enzymic oxidation following bruising of the fruit and processing delays was therefore confirmed. Supplementary damage occurs in the repeated handling with concomitant contamination with iron and atmospheric oxidation.

The nature of the colouring matter remaining after earth bleaching has been investigated. Two samples, one with good, the other with poor bleachability were bleached to the same fesidual colour (100 units on the Lovibond scale) by using 3 and 5 per cent of earth respectively. The absorption spectra of both bleached oils showed that they contained a complex mixture of pigments, but the inferior oil contained about twice as much material absorbing at 350 mμ and half as much absorbing at 450 mμ as the better oil. It seems likely that oxidation products of β-carotene would absorb at the shorter wavelength but since the oxidation products of β-carotene are usually more firmly adsorbed on earth than is the original pigment this can hardly be the full explanation of the difficulty in bleaching oxidized oil.

One reason may be that in oils which are difficult to bleach, the pigment remaining after normal earth bleaching is associated with the fatty acid. If the oil is saponified, coloured fatty acids are obtained and it may well be that the oxidized linoleic acid combines with the carotenoid pigments possibly also in the oxidized state. This problem is still being studied.

Practical recommendations that follow from this work are:

(1) In order to produce oil of good bleachability enzymic and other forms of oxidation must be minimized. Since destruction of the lipoxidase also involves lipases, oil of good bleachability usually possesses a low acidity (often near or below 1 per cent). Oil of good quality can be produced either on the plantation scale or in peasant production, but it is not clear whether the increased fuel costs for bunch sterilization and the capital outlay necessary—especially on a plantation scale—to speed up the process of extraction, would be outweighed by the increased value of the product. The product would command a higher price both on account of its better bleachability and also because of its lower acidity. Some commercial deliveries of such oil have already been made from the Belgian Congo. The results of an examination of a sample in our laboratory gave the results, shown in the table, in comparison with oil produced experimentally in Nigeria.

Comparison of Specially prepared Commercial Congo Oil with Experimentally Produced Nigerian Oil

Sample	Free Fatty acid as palmitic acid *per cent*	Peroxide Value ml. of 0·002N sodium thiosulphate	Absorption (*a*) at 230 mμ	Carotene content mg./kg. (p.p.m.)	Residual Colour (*b*) after Bleaching		
					With Earth 105°C	With Heat	With Heat and Earth
Congo Super Oil S.P.B. from Lukumete . .	1·0	0	1·84	553	9	83	24
Specially prepared Eastern Nigerian Oil .	0·1–3·0	0–2·1	1·58–1·78	622–1547	3–32	38–108	16–29
Specially prepared Cameroons Oil — Series A	0·3–0·4	0	1·52–1·77	478–946	4–9	78–105	16–22
Specially prepared Cameroons Oil — Series B	0·9–1·5	0–2·3	1·45–2·26	339–757	3–25	80–84	17–25

(*a*) Extinction coefficient at 230 mμ per cent 1 cm. cell determined spectrophotometrically.
(*b*) Given as (10 × Red Lovibond Units + Yellow Lovibond Units) for a 1 in. cell.

(2) The deeper the colour of an oil the more earth is required for effective bleaching. Further, since the more highly pigmented oil is more liable to suffer carotenoid oxidation it probably has a greater tendency to deteriorate in bleachability during processing. This is believed to be one reason why the more highly-coloured Nigerian plantation oil is frequently difficult to bleach as compared with that from Malaya and the Cameroons. The evidence concerning this is somewhat confusing since highly-pigmented oil is frequently derived from fruit with a thin easily-damaged pericarp. However, since most of the oil will, in future, be bleached attempts should be made to introduce a palm with a less high-pigmented oil and thicker pericarp than is commonly grown in Nigeria. A long-term aim would be to introduce a palm yielding an oil containing 500 p.p.m. or less of carotene.

Further study has also been given to the lipolysis of palm oil especially during its storage after the processing of fruit. Reference has already been made to the work of Fickendey, Barnes and others on the importance of lipases but even when these enzymes have been rendered inactive hydrolysis can occur in the oil and this has been shown to be of commercial interest.

Loncin[55,56,57] has studied the hydrolysis which can occur in the presence of water only and has shown that, provided palm oil is saturated with water, further addition of water has little effect on the rate of lipolysis. Under conditions of constant temperature, the rate of lipolysis of water-saturated palm oil is defined by the differential equation $\frac{dF}{dt} = KF$

where F represents the acidity of the oil (for values of F below 5 per cent), K is a constant, and t represents time.

In this respect the lipolysis of palm oil follows that of the fat present in cotton seed;[58] as with chemical oxidation, chemical lipolysis is an auto-catalytic reaction, the product of the reaction being one of the main factors affecting its speed. Another factor affecting speed is temperature and since palm oil is stored for long periods in the tropics and has to be melted before it can be pumped, chemical hydrolysis of palm oil, whilst not very different from that of other oils, is more important commercially.

Practical recommendations which can be made from the results of this work are that as much moisture as possible should be removed from the oil (say to below 0·1 per cent) and heating should be reduced to a minimum. Whilst the importance of the initial acidity of the raw material has long been recognized for cottonseed, it is doubtful whether this factor has been evaluated fully for the storage of palm oil.

A. Desassis[59] has published tables showing the increase in acidity that can be expected from palm oil of different acidities when stored under defined conditions. D. G. Coursey[60] of the West African Stored Products Research Unit, who has studied the increase in acidity in oil stored mainly in metal drums on the coast in Nigeria, has reported an irregular and much greater increase than those postulated by Desassis. Some of his results are summarized.

Increase in Acidity of Palm Oil
(Expressed as per cent palmitic acid)

	Initial Acidity	*Increase*
8 drums stored at Umuahia for 100 days. .	3·5 to 3·9	0·2 to 1·6
2 drums stored at Umuahia for 100 days . .	4·3, 5·1	0·9, 1·4
Pioneer Oil Mill Oil stored at Port Harcourt for 92 days	2·9 (mean of 12 drums)	0·8
Special Palm Oil stored at Port Harcourt for 100 days	3·8 (mean of 10 drums)	1·1
Technical Palm Oil stored at Port Harcourt for 100 days	9·9 (mean of 5 drums)	1·4

He has also shown that when the oil is heated and subsequently stored under sterile conditions the increase of acidity is less than for untreated oil. Coursey therefore concludes that microbiological action is an important factor in the lipolysis of peasant-produced palm oil in Nigeria.

At the present time the Institute is collaborating with the West African Stored Products Research Unit and the Biology Department of the University College, Ibadan, in a further study of the nature of the organisms found in palm oil and their importance to its lipolysis. Organisms so far isolated include moulds belonging to the *Aspergillus* and *Penicillium* genera, but it is too early to assess the importance of these organisms in the commercial deterioration of palm oil.

A paper by D. G. Coursey and H. O. W. Eggins of University College, Ibadan, reports on the examination of 232 samples of palm oil.[74] They found the four most frequently occurring organisms were *Baecilomyces*, two species of *Aspergillus* and *Rhizopus*. These occurred in 10 to 20 per cent of the material examined. Samples of sterile palm oil were then inoculated with these moulds after their moisture contents had been adjusted to 0·5, 1, 2, 4 and 8 per cent. They were then stored at a tropical room temperature of about 25°C for 8 weeks, and their acidity was compared with sterile control samples containing 2 per cent of moisture. The increase in acidity above that of the control varied between 0·5 and 3·2 per cent, calculated as palmitic acid, being greatest for *Aspergillus niger*.

In addition, a great deal of work on the agronomic side has been completed by the West African Institute for Oil Palm Research at Benin and by the Agricultural Research Services in Malaya and elsewhere (including Inst. Nat. agron. Congo belge in the Congo).

Studies have also been completed by Unilever and other commercial organizations who are concerned with oil palm plantation management. However, it is not proposed to review this work in detail but mention may be made of papers which have appeared by Purvis[61] on pollination, Hussey and Rees[62] [63] [64] on germination, Bull and others[65] [66] [67] [68] [69] [70] on oil palm diseases, Sparnaaij[71] on bunch production and Hartley on the improvement of groves[72] [73] as examples of the problems which are currently under examination.

Since the oil palm trade with Europe was launched, in a space of little over 100 years the application of scientific methods to the industry has resulted in spectacular advances. Yields per acre have increased several-fold and there have been remarkable improvements in the efficiency of oil recovery from the fruit, but perhaps it is in the field of quality, associated with deterioration due to chemical and enzymic changes, that

the greatest advance has been made. The bulk of the oil now marketed contains less than 5 per cent of acidity (calculated as palmitic acid), instead of the 50 per cent so often found in the early shipments.

Whilst further improvements in yield, extraction efficiency and quality are possible the law of diminishing returns can be expected to apply and an increasing amount of scientific knowledge will be required to maintain continued improvement. However, there is no lack of problems which await solution and it is hoped that means will be found to investigate them and that new techniques will be applied under not too violently changing conditions in the countries where this bountiful source of oil grows.

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Book Reviews

THE WEALTH OF INDIA. Industrial Products Part V: I-L (with index) Chief Editor, B. N. Sastri, xiii + 289. 11 × 9. (New Delhi: The Director General, Council of Scientific and Industrial Research, 1960.)

The high standard reached by earlier parts of this series* is well maintained in the present volume. It is lavishly illustrated with black and white photographs and diagrams as well as several colour plates.

As in the earlier parts, the development of industries has been traced and their present position described. Articles dealing with 24 industries indicate the principal raw materials and their sources and describe manufacturing processes.

Insecticides

The entry runs to about 25 pages and includes sections on fungicides, herbicides, and rodenticides. Following some paragraphs on the chief inorganic and natural insecticides, there are tables giving data on the synthetic organic materials, such as DDT, BHC and the organo-phosphorus insecticides (one unfortunate error here is the description of dieldrin as an ethoxy compound). Several of the more important substances are now being manufactured in India, and some account of the production processes, with flow sheets, is given. Much statistical information is contained in several tables which detail recent Indian usage of pesticide materials along with production, import and export figures. It is an indication of the development of the Indian chemical industry that in 1958 over 3,000 tons of BHC and 1,700 tons of DDT were manufactured.

Oils and Fats

No specific oils and fats are described, but there are references to their use in the sections headed Ink, Printing, Linoleum and Lubricants. In the cheaper newspress printed today, printing ink only needs to be absorbed by the bibulous paper and a cheap mineral oil is therefore often used. However, linseed, tung, dehydrated castor and similar oils are used in those inks which dry on the paper. Although printing ink for letter-press work has long been manufactured in India, it was not until after World War II that printing ink was manufactured there in any quantity.

Lac

Particular attention is given to a description of the methods employed in preparing the various forms of refined lac, and to a comprehensive review of the chemical and physical properties of shellac. A section on the thorny problem of grades and specifications includes an International Standards Organization draft specification for seedlac and shellac, which is prominently summarized in tabular form. It should be borne in mind that this only a draft; at the time of writing it is still the subject of discussion between member countries of I.S.O.

Reference is made to the great decline in the use of shellac in the manufacture of gramophone records. The main outlet for shellac nowadays is in the manufacture of varnishes, lacquers and polishes; it is still of importance in the electrical industry, and many of its multitudinous minor uses are mentioned. The monograph closes with a résumé of India's trade in lac from 1934 to 1958.

Jute Mill Industry

An account of the industry which dates from 1855 when a mill was erected near Calcutta using machinery imported from Scotland is given. A description of the raw material and the uses to which the different grades of fibre are put follows. The manufacture of jute goods is described in more detail but while this

* Previous volumes were reviewed in *Trop. Sci.*, 1960, **II,** No. 3, 168., *Trop. Sci.*, 1959, **I,** No. 3, 220, *Colon. Pl. Anim. Prod.*, 1952, **III,** No. 3, 362, and *Colon. Pl. Anim. Prod.*, 1950, **I,** Nos. 1 and 4, 78, 326.

section contains much useful information it is felt that its value to the general reader would be enhanced if it contained more diagrams. For example, a diagram showing the sequence of operations from the batching of the raw fibre to the spinning of yarn and also one of a carding machine would be useful. And while the photograph of 'jute yarn being wound in spools' (Plate V) is excellent the one of 'feeding jute fibres to the breaker card' (fig. 42) leaves much to the imagination. The wide variety of products made from jute is listed and tables are given of production and export figures for manufactured jute goods.

Jute pressing and baling is an important industry in India and the information about it is almost certainly not to be found elsewhere in such a convenient form.

The name 'Khadi' or 'Khaddar' is applied to silk, cotton and woollen materials woven on hand looms from hand spun yarn. An interesting account is given of the traditional industry which, although it cannot compete economically with mechanized cloth production, is supported by subsidies to provide employment in villages.

A.J.F., W.D.R., E.B., and C.G.J.

THE PINEAPPLE. By J. L. Collins. World Crops Books, xvii + 294 pp. 9½ × 6. (New York: Interscience Publishers Inc., London: Leonard Hill (Books) Ltd., 1960.) Price 60*s*.

This volume forms one of a series of general handbooks on individual crops or groups of crops of world importance. The book is divided into three parts which cover the botany, cultivation and the utilization of the fruit. The botany section starts with a most interesting chapter on the history of the pineapple, which originated in America and was unknown to Europeans until Columbus discovered it on the island of Guadeloupe. The fruit excited great interest and enthusiasm among early travellers to the Americas and, as a result, was soon introduced to many other tropical countries along the shipping routes of the sixteenth and seventeenth centuries. Since then production has expanded and it is nowadays one of the most important tropical fruit crops.

Other aspects of the pineapple dealt with in the first part of the book include a detailed description of the taxonomy, origin and ecology of the plant. The author emphasizes the importance of the Smooth Cayenne variety in the chief production areas of the world and gives an account of the morphology and anatomy of the Cayenne under Hawaiian conditions. As would be anticipated, the cytology and genetics of the pineapple and breeding techniques are dealt with in great detail by Dr. Collins, who is a geneticist, and the chapter provides a very comprehensive account of these aspects of the pineapple. In particular, attention is drawn to the importance of fruit quality in developing new varieties and the author has compiled a useful table showing both the desirable and undesirable characters of some five varieties and four species.

The first chapter of part two of the book deals with the commercial cultivation of the pineapple in the main producing areas of the world and Dr. Collins is to be congratulated on collecting detailed information from a large number of sources and providing such a concise account of the production of pineapples in various areas. In particular, the account of the specialized methods used in the Azores to produce high quality fruit in glasshouses, for export to Europe, is most interesting, since information relating to this industry is not readily available. Other chapters in this section review the diseases, pests and abnormalities of the pineapple and the effect of environment upon its development.

Part three of the book deals with the various products obtained from the pineapple. Pineapples are the second most important of the canning fruits and world output in 1958 was estimated to have amounted to over 440,000 tons. In view of this, the account of the processing methods used to can the fruit is very brief and it is perhaps a little disappointing that the author has relied heavily upon a ten-years-old report of the Hawaiian industry for this section. An interesting point to which Dr. Collins draws attention is the effect of prolonged storage upon the quality of canned pineapple, especially the effect of temperature upon the inversion of the sucrose present. Other products briefly mentioned are pineapple crush, beverage juice and frozen pineapple slices.

An important factor in the processing of pineapples is the high percentage of waste material obtained and the Hawaiian industry has carried out a good deal of research work to develop by-products. In a specially-contributed chapter, the methods used to produce a canning syrup, cattle food and organic acids in Hawaii are outlined, and mention is made of the possible utilization of the pineapple as a source of fibre, proteolytic enzymes, waxes, sterols and starch.

Since Dr. Collins' book is the first comprehensive work on the pineapple to be published for 25 years it will be of great value to all concerned with this fruit crop. It should be noted, however, that many of the aspects concerning the marketing of pineapples as fresh fruit have been omitted, although the production of fruit for the fresh fruit trade is of considerable interest in several producing countries.

The book is well produced and generously illustrated with clear photographs, the selection of which has obviously been carried out with great care.

D.K.

THE TECHNOLOGY OF WINE MAKING. M. A. Amerine and W. V. Cruess, xiii, 709 pp., 6¼ × 9¼. The Avi Publishing Company Inc. Westport, Connecticut, 1960.) Price, U.S.A., $19, outside U.S.A. $20.

This book is essentially a new edition (the third) of the senior author's *Principles and Practices of Wine Making* (1947) and there does not seem to be much reason for changing the title. However, the work is a most valuable one and compresses an immense amount of information within its 700 pages. Naturally, it is written from the point of view of the United States producer, particularly the Californian one, but gives a valuable account of regions, production methods and winery techniques in all the wine countries of the globe.

The world production table itself sets the framework of the book because, although we are accustomed to thinking of wine being produced in California in immense tanks and on a vast scale, yet the actual production in the U.S.A. is comparatively small (147 million gallons) compared to France and Italy (1,208 million and 1,779 million gallons respectively). It is interesting to note that the U.S.A. and the U.S.S.R. each make about the same quantity of wine. However, the U.S.A. gets its crop from a quarter of the U.S.S.R.'s area of vineyards.

One is glad to see that, whilst the authors respect European wine-making (for example they record that three quarters of the world's wine is produced in Europe), they advise growers to avoid slavishly imitating European wines, a fact which growers outside Europe should always bear in mind. There are many splendid vine zones outside Europe and the U.S.A.—Argentina, Australia, Chile, for instance—where wine grapes will grow well and produce vintages which should be known for their own local qualities not because they imitate other wines.

The whole range of the technology of wine-making is covered, starting with the composition of the grapes, and continuing with the moulds and yeasts and then the chemistry of fermentation. This last is an admirable chapter containing both the history of the subject and an account of the latest discoveries. There is a concise account of the numerous substances found in wine, ranging from the alcohols to the trace elements themselves. The technology of wine production occupies a large section of the book, including the making of fortified wines, vermouths and fruit wines; it is followed by sections on spoilage (bacterial and non-bacterial), brandy, by-products, analysis, and legal restrictions in the U.S.A., though even here the bibliography gives the main references to the laws of other countries.

There are many observations of interest to the would-be or actual tropical wine-maker: for instance, Brazil is already producing 30 million gallons of wine a year. However, she is obliged to use the *labrusca* grape, although experiments with the French 'direct producers' are in hand. It seems to this reviewer that, in the same way that hybrids can be raised to suit colder regions (such as Baco No. 1), so could they be bred for use in tropical ones. The writer knows of at least one man experimenting with wine grapes in Kenya. At present Isabella and Herbemont are the main Brazilian varieties, both having the foxiness of the

labrusca wine, but nevertheless giving a wine with its own character which is obviously appreciated, as the quantity produced shows. The defects which the would-be tropical producer must overcome are low acidity and high tannin in the wine.

The chapter on fruit wines is of interest to the tropical agriculturalist; for instance a wine can be made from pineapples and the waste cores and trimmings from canneries can be used for this purpose, or the wine so made can be subjected to acetic fermentation and used for the production of distilled vinegar. There are also notes on the use of citrus, for wine and orange brandy and on dried fruits, such as figs, dates and raisins, for the same purpose. Unfortunately, the book has nothing to say about palm wine.

There are, of course, descriptions of many procedures which the European wine-lover would regard with horror, for example, bulk pressure fermentation for sparkling wines, rapid ageing by the use of oak shavings instead of barrel storage, baking of wine to produce sherries, and so on, but before we can justify such an attitude we must ask ourselves whether it does not proceed from prejudice and conservatism. The test is—are wines produced by unorthodox methods healthy and agreeable? Many undoubtedly are and there is consequently no reason to oppose such methods if they produce good wine. In fact, however, many of the old methods, on the showing of this work, still hold their own: the authors point out (p. 175) that there is no good substitute for SO_2 and that Captan as a spray for vines can interfere with fermentation whereas the old Bordeaux mixture does not.

The book is a most valuable compendium of information; it suffers in places from careless proof reading—for instance, the figure references, in the section on Spanish sherry, p. 359, are all wrong—but nevertheless it is a work of immense value to all wine producers.

G.O.

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Compiled by Miss V. Clarke

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